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TECHNOLOGY TRANSFER IN RESEARCH AND DEVELOPMENT

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EDITED BY

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Proceedings of the Briefing on Technology Transfer Projects, organized by the Naval Postgraduate School, Monterey, California, sponsored by the Naval Material Command, Wash. D.C., and the Naval Facilities Engineering Command, June 9, 1975, at Naval Material Command Headquarters, Wash. D.C.

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PREFACE

During the past few years there has been a growing interest in the secondary use of research and development output. If the output from a research effort, over and beyond its initial specific mission, can provide technology that is productively used in many locations and/or by a number of organizations, then the original cost of the research can be viewed as providing a substantial contribution over and above its primary task to satisfy a specific and defined need. Secondary utilization of research and development has attracted the attention of the President of the United States, the Department of Defense and the individual Services as a logical method of enhancing the productive output of research and development effort.[1 2 3]

Several sectors of the Navy have taken an active role leading toward more effective use of research and development output. Three such efforts are appropriate to be mentioned here: (1) The Headquarters, Naval Material Command, Washington, D.C. has been developing communications networks and technology documentation and distribution systems specifically directed toward the enhancement of the use of research and development output. (2) Certain faculty of the Naval Postgraduate School, Monterey, California have been investigating the processes, concepts, framework and methodology of technology transfer. (3) The Headquarters, Naval Facilities Engineering Command, Washington, D.C. has conducted several studies and has introduced several programs within its command that deal directly and specifically with the desire to enhance the utilization of research and development output.[3]

This book is a documentation of the papers presented at the June 9, 1975 one-day briefing jointly sponsored by the Naval Material Command, the Naval Facilities Engineering Command and the Naval Postgraduate School.

The intent of the one-day briefing was to present to interested persons a review of the progress being made in understanding the processes, concepts, framework and methodology of technology transfer. The approach was to present both theoretical work and practical case histories demonstrating the use of the theory.

There are relatively few centers in the United States doing what is sometimes called, "Research on Research" or more specifically research on methods of enhancing the utilization of research output. In addition to the Naval Postgraduate School, one of the centers that is concentrating considerable effort on this subject is the University of Michigan Center for Research on Utilization of Scientific Knowledge (CRUSK). The work of CRUSK with the U.S. Forest Service (USFS) has resulted in interesting new methodology and meaningful case histories. Because of this Dr. David Lingwood of CRUSK and Mr. Hal Marx of the USFS were invited to participate in the one-day briefing.

Rear Adm. C. P. Ekas USN, Director of Technology Transfer, Headquarters, Naval Material Command, was the host. The briefing was held at the command briefing auditorium at Crystal City Plaza, Arlington, Virginia.

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[1] President's message to Congress, March 1972

[2] Deputy Secretary of Defense memo to military services, June 21, 1972.

[3] Accounting Office Report (GAO), December 29, 1972.

All of the papers presented at the briefing were recorded on audio tape. These were then transcribed and a transcription was sent to each author for editing. The syntax of each paper as it appears here is the author's choice. Some of the papers are essentially a verbatim transcription of the author's speech, while others have been edited to have a syntax akin to a paper prepared for a technical journal.

The printing of this book on technology transfer papers is the joint effort of the Naval Postgraduate School and the Naval Material Command, Washington, D.C.

As editors it is appropriate and with sincere appreciation that we extend thanks to each of the authors whose papers appear in this book, to Rear Adm. C. P. Ekas, Mr. Perry Newton, Ms. Sterling Atchinson and Ms. Linda Massaro of the Naval Material Command, Washington, D.C., and to Capt. Vince Skrinak and Mr. Tim Rohrer of the Naval Facilities Engineering Command.

Monterey, California
December 1975

J. A. Jolly, Ph.D.
J. W. Creighton, Ph.D.
Editors

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1. THE LINKER ROLE IN THE TECHNOLOGY TRANSFER PROCESS

by

M. E. Essoglou

Assistant Commander for Research and Development, Plans and Programs Division, Naval Facilities Engineering Command Headquarters, Washington, D.C.

This morning we hope to tell you why the Naval Facilities Engineering Command (NAVFAC) embarked on the series of studies and other efforts bearing on the subject of technology transfer. We have also included in our program today one case history of a specific technology transfer event. However, the main thrust of our presentations is essentially intended to tell you what we have done in terms of organizational considerations, behavioral considerations and the kinds of things that really constitute the technology transfer problem.

Before discussing my main topic, I feel it is necessary to give you a brief chronology of certain events that the Assistant Commander for Research and Development of the Naval Facilities Engineering Command has been essentially responsible for since about 1962. Those of you familiar with the literature on technology transfer will see that there is some correlation between the distribution of various books and papers on the subject of technology transfer and the apparent timing of our management actions as reflected in the dates shown in Figure 1-1. This figure shows that in addition to sponsoring studies at the Naval Postgraduate School (NPS), we have taken a number of other actions, partially as a result of the guidance indicated from the NPS studies, and partially from our own knowledge and reading of the general literature and our intuitive perception of what we thought we should be doing to enhance technology transfer in the NAVFAC family of organizations. I would like to point out that these events indicate an awareness of technology transfer as a conscious type activity as opposed to the more random, traditional technological diffusion. Our awareness that people, and people to people type contact, is the way to solve most of these problems as opposed to the more formal bureaucratic type approaches, is also reflected by some of our actions shown in Figure 1-1.

1. RDT&E Assistance (1962)
2. RDT&E Utilization (1964)
3. Mandatory Task Proposals (1965)
4. Technology Transfer (1966)
   A. Applications Division
   B. RDT&E Liaison at Field Level
   C. NASA and Other Programs
5. CEL Report Utilization
   A. Naval Postgraduate School (NPS) (1967-70)
6. NPS Technology Transfer Study (1970)
7. CEL Field Engineering Support Office (1971)
8. RDT&E Assistance Doubles— $100 to 200 K (1971)
9. CEL/NAVFAC Workshop (1972, 1974)

Figure 1-1 Chronology of NAVFAC'S Technology Transfer

Let me explain what we mean by RDT&E assistance and RDT&E utilization. The user is generally a man in one of our field offices. These users of our technology have always felt that the Civil Engineering Laboratory (CEL) never quite solved the problem of a given research task fast enough to make the results useful for his operating needs. Therefore, to make laboratory expertise readily available, we set up the RDT&E Assistance Program by setting some money aside for laboratory personnel to answer, on short notice, questions raised by the field. The RDT&E Utilization Program refers to efforts in our Headquarters such as the establishment of a division responsible for the utilization of the research output of the laboratory. This program was a Headquarters function whose mode of operation was primarily through administrative tools like instructions, memoranda, etc.

Notice that while it focused on the problem, its separateness from the "people agents" in the producer-user dialogue provided the seeds for its failure and discontinuance by 1966.

We went through a phase about 1965, where it was clearly recognized that if the customers had input in formulating the research program the odds were that the output would be utilized more readily. We went through a typical bureaucratic routine where we required all field activities to submit a minimum number of proposals per year. Well, needless to say, that did not work, because we immediately were swamped with proposals and had to screen out most of them and show that they were not worthy of pursuit.

Awareness of technology transfer in NAVFAC, as far as I can determine, dates back to 1966. A number of independent initiatives relating to technology transfer took place in 1966. As history of technological innovation amply documents, technology transfer and innovations usually happen when several people in an organization, or even far apart, exposed to various ideas in their own spheres of the operation tend to converge on the same idea or development. As it is also well known, innovation needs a champion during its early infancy stages. For example, the Applications Division was established in the office of R&D at the direction of the "boss", a Rear Admiral who was at that time Deputy Commander for Acquisition where R&D is located.

The RDT&E liaison effort at the field level, on Figure 1-1, is something for which I have to take the blame. During the R&D Utilization era we were concerned with the vertical flow of information that came in from our Laboratory, and getting it into the Command's business. The mainstream of NAVFAC's business is writing specifications for procurement of various items that are constructed or manufactured. R&D utilization activity was essentially confined in the Headquarters. More than three-fourths of the engineers in the NAVFAC organization are located in the Field Divisions, i.e., Philadelphia, Norfolk, Charleston, San Bruno, and Pearl Harbor. It was apparent that the organization was literally cut out of the process of introducing new technology. A new technology or idea had to go from the laboratory to the Washington level, and from the Washington level it had to be promulgated out to the field. We all know that it is the man in the field who feels the pain of unsolved technical problems and has the need to implement an innovative and promising solution. It is not so for the bureaucrat in Washington who for many good reasons acts as a stabilizing agent in promulgating and maintaining policies. Through the establishment of the RDT&E Liaison Officer, at each one of our Field Divisions, we felt that we would by-pass some of the inevitable though unconscious barriers that the Washington Headquarters interpose. In brief, we felt that since we operate mainly as a decentralized organization, why not let the R&D program planning and utilization go somewhat decentralized. Other advantages that the R&D Liaison Program had over the old Utilization Division were: (a) fostering a mechanism of inter-field division transfer of innovative solutions generated in the field, and (b) eliminating Headquarters jealousy as to who should be in charge of the utilization business, R&D or Engineering.

In 1967 one of our Assistant Commanders became quite sensitive to the problem of unused technology and directed our Laboratory to undertake a conscious effort to determine to what extent technical reports were being utilized. The Laboratory turned to the Naval Postgraduate School in the 1967-1969 period. Most of the Postgraduate School effort did not start however until 1970. Again to use a phrase that has appeared in the literature "every invention needs a champion". In the Navy you need aggressive and innovative people to champion new ideas and approaches. Around 1970 we were fortunate enough to have such a person in the Assistant Commander for Research and Development. He felt that we should initiate a "research on research" effort at the Naval Postgraduate

School directed towards NAVFAC's needs. In 1971, the new Commanding Officer of the Naval Civil Engineering Laboratory noticed that while we had made provisions to deal with this transfer problem in Headquarters and at the Field activities, in his own laboratory he could not find a focal point. As a result, he established the Field Engineering Support Office (FESO) whose sole purpose was to see that the customers in the field were satisfied and got the information they requested in a timely manner. This focal point in CEL now serves as a "linker" or a "gatekeeper". (Gene Early, who has headed that office, will elaborate on this in another paper.) Since answering questions does take time, and the mode of industrial funding of Navy laboratories does not allow a man to take time from his assigned tasks unless he has something to charge that time against, it became evident that specific resources available at the Laboratory to make quick advice possible had to be increased. The earmarked RDT&E Assistance fund was then doubled.

In 1972, and again in 1974, we pulled together the entire NAVFAC community of people working on technology transfer, i.e., Civil Engineering Laboratory personnel, the RDT&E Liaison Officers from our Field Divisions, Headquarters personnel, and the Naval Postgraduate researchers. We held workshops exchanging views, experiences and frustrations.

This is a thumbnail sketch of why and how we got where we are today.

The Postgraduate School Studies

Figure 1–2 shows the studies that have been carried out by the Naval Postgraduate School (NPS). In my talk this morning, I will concentrate on the work done on the two particular studies which we feel are really the mainstream of the NPS work. These are: ENHANCEMENT OF RESEARCH AND DEVELOPMENT OUTPUT UTILIZATION EFFICIENCIES: LINKER CONCEPT METHODOLOGY IN THE TECHNOLOGY TRANSFER PROCESS, by J. W. Creighton, J. A. Jolly, S. A. Denning, 30 June 1972 and TECHNOLOGY TRANSFER AND UTILIZATION METHODOLOGY; FURTHER ANALYSIS OF THE LINKER CONCEPT, by J. A. Jolly, J. W. Creighton, 30 June 1974. We went to NPS for this work because it became apparent that our prior approaches to technology transfer problems lacked the skill of the kind of people who are trained in behavioral science. By seeking the assistance of the School of Operations Research and Administrative Science at the Naval Postgraduate School, we would get the people whose background and training would allow them to attack our problem from a point of view slightly different from that of the typical "physical science" oriented engineer. Further we reasoned that since these people were essentially in an in-house Navy graduate school, with familiarity of the Navy system, we could get more for our money. They, more than any other faculty, might have a better feeling for the kind of organization and the kind of person we have in the Navy Department. Yet another reason for going to the Naval Postgraduate School was the fact that the Navy sends several hundred Naval officers (not only Civil Engineer Corps) through this school every year, and the mere exposure of these graduate student officers to the problems and concepts of technology transfer would have a rapidly multiplying beneficial effect when they would return to the Fleet, Washington or other field activities throughout the Navy. As we look at our results, I am personally inclined to feel that the exposure of several hundred officers a year to technology transfer topics, issues, readings, and projects has sensitized these people to this particular issue. If nothing else comes from this research, this training value alone will bring payoff to the Navy in the years to come in ways that we may never be able to trace. Last, but not least, doing business with NPS is

bound to have benefits resulting from the accumulation of studies. The result is the development of an in-house Navy cadre of expertise in this area.

1. *UTILIZATION OF CEL TECHNICAL REPORTS*, Naval Postgraduate School, 1969.
2. *DISTRIBUTION OF CEL TECHNICAL REPORTS*, Naval Postgraduate School, 1970
3. *ENHANCEMENT OF RESEARCH AND DEVELOPMENT OUTPUT UTILIZATION EFFICIENCIES: LINKER CONCEPT METHODOLOGY IN THE TECHNOLOGY TRANSFER PROCESS*. Naval Postgraduate School, NPS-55CF72061A, June 1972 (AD 756-694)
4. *FESO PROJECT EFFECTIVENESS PROFILE, SUMMARY AND ANALYSIS OF 1972 QUESTIONNAIRE RESULTS*, October 1973
5. *TECHNOLOGY TRANSFER AND UTILIZATION METHODOLOGY: FURTHER ANALYSIS OF THE LINKER CONCEPT*. Naval Postgraduate School, NPS-55J074061, June 1974 (AD A003-867)
6. *FESO PROJECT EFFECTIVENESS PROFILE: SUMMARY AND ANALYSIS OF 1973 QUESTIONNAIRE RESULTS*, September 1974
7. *INVESTIGATION OF INSTITUTIONAL AND BEHAVIORAL BARRIERS TO TECHNOLOGY FLOW AND UTILIZATION*, December 1974
8. *AN EVALUATION OF THE EFFECTIVENESS OF A RESEARCH ORGANIZATION'S MECHANISM FOR TRANSFERRING TECHNICAL INFORMATION TO APPLIED END USE*. Naval Postgraduate School, 55J074121, December 1974 (AD A003-501)
9. *THE POWER LINE DISTURBANCE MONITOR: A CASE STUDY OF THE NAVY'S CONTINUING EFFORTS IN THE FIELD OF TECHNOLOGY TRANSFER*. Naval Postgraduate School, NPS 55J075031

Figure 1–2 NAVFAC Technology Transfer Studies by the Naval Postgraduate School

Having provided the background history of NAVFAC's involvement, now let's look at the results of our studies. Technology transfer takes place when there is a source, a transfer mechanism of some sort, and utilization of the knowledge (Figure 1–3). The process may be quite complex but in the simplest sense this is what we are talking about. I would like to point out that this model, Figure 1–3, is essentially true whether we are talking about the vertical flow of technology, i.e., from a laboratory to a given application, in a given discipline, or the horizontal transfer of technology, as from one industry or activity to another. In all cases the source must emit a signal which the user must then receive and respond to it. It can then be said that technology transfer has occurred.

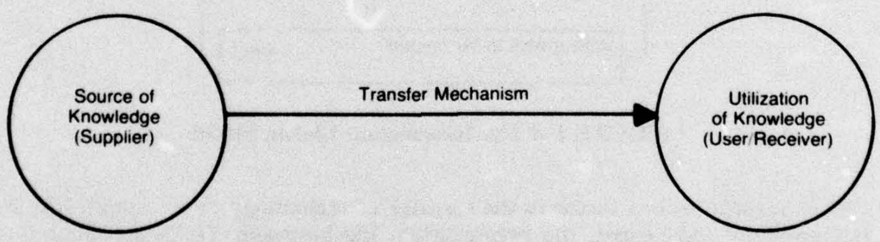

Figure 1–3 A Simple Technology Transfer Model

The "linker" model was developed by Professors Jolly and Creighton and LTJG S. A. Denning, who was then a student. The elements in the linker model are shown in Figure 1–4. The model essentially says that all of these factors affect the transfer mechanism. Now, if we knew how and how much these factors affected the transfer mechanism in a given organizational situation, we could modify them by direct management action based on fact rather than intuition or guess. Needless to say, quantifying this particular model has not been done. It is a tough job to do, and whether it will ever be done is questionable. In any case, this

model serves as a very useful conceptual framework around which we can organize our thinking and approaches to the problem. I would like to briefly describe the elements of this model.

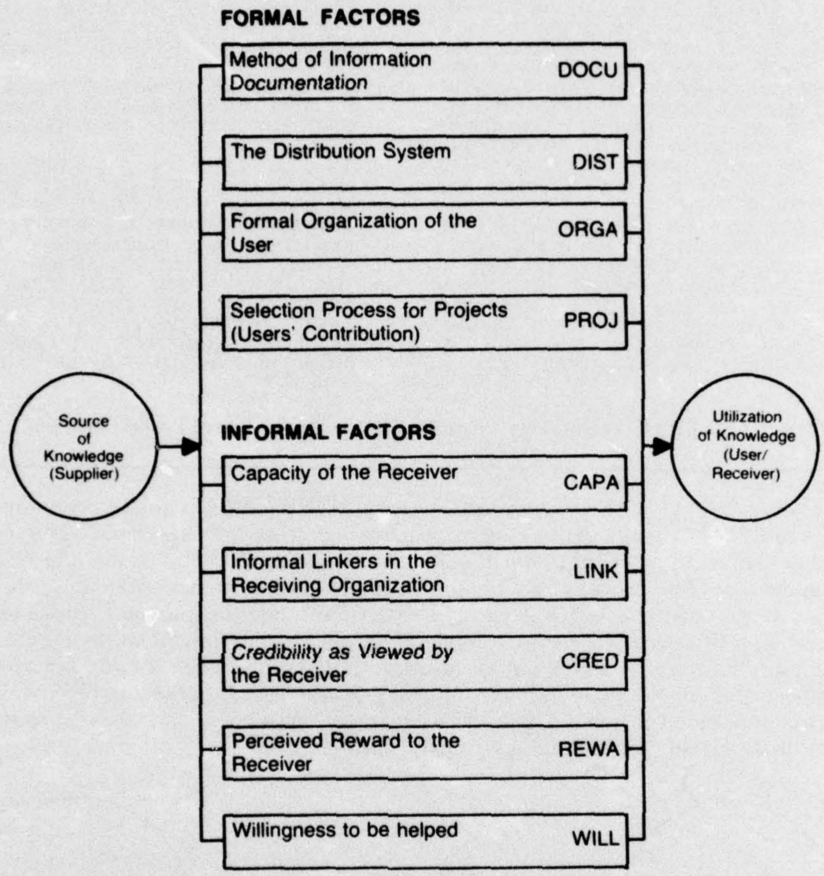

FIGURE 1–4 The Information Linker Model

Documentation is a factor in the transfer of technology. Very simply we are talking about the format, the organization, the language. Does the laboratory write a report that can only be understood by people in another similar laboratory, or does it write a report that can be understood by a practicing engineer?

Distribution deals with the physical channels used to distribute the information—the entry, the exit, the plan, redundancy. This is perhaps the easiest to measure or appraise.

Organization plays a very important part in determining how the technology is going to get transferred, if at all. The power structure, the nature of the business, the management style, resources, attitudes, bureaucratic tendencies, and state of equilibrium. These kinds of things need to be measured or appraised, if we are to quantify this factor called organization, obviously the prospects for success are difficult.

Project selection. This factor concerns who initiates the project, who approves, who authorizes, who monitors, and who is consulted about the project. Project selection is very critical in the ultimate utilization of research. One tends to utilize that which he helps develop.

Professor Jolly has seen fit to divide these factors into formal and informal as shown in Figure 1–5. Formal factors are things we can lay our hands on, the kinds of things we can operate on fairly directly. They are really system oriented. The informal factors are highly behavioral and sociological and therefore quite tough to handle. This is perhaps one of the reasons why the Federal Government has concerned itself mainly with formal documentation, storage, and distribution assistance, like the Defense Documentation Center and has ignored the informal factors. This observation, I believe, was made by Samuel Doctors in his 1969 book "The Role of Federal Agencies in Technology Transfer". It would seem that if reports and papers were available on the desks of the engineers and scientists, technology would be transferred. This is not the case. We must recognize

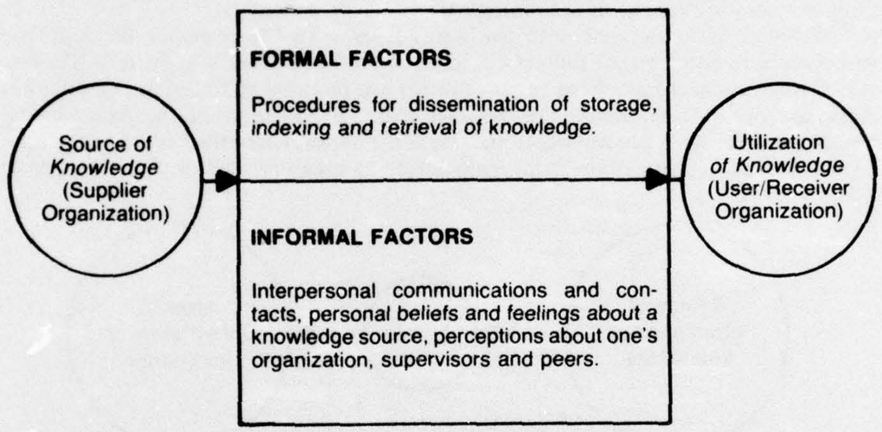

FIGURE 1–5 Knowledge flow enhancement factors divided according to formal vs informal.

that the problem has two dimensions. One that is fairly manageable is the question of storage and distribution of technical information through various information systems. It is a relatively straight forward problem, however complex. The second dimension is the set of items called "informal factors", which deals with perceptions. It gets quite a bit more complicated when trying to manage such a set of factors because its science base is primarily behavioral rather than physical. Let's now look at these "informal" factors.

Capacity refers to characteristics of individuals in the user organization that are described by terms like venturesomeness, wealth, power, education, experience, age, self-confidence, etc. Obviously these characteristics are vague and difficult to translate into quantifiable variables for analysis or design purposes. Yet they are very important in the transfer process.

The *linker* is essentially the individual or group of individuals who does exactly what the term implies. It is probably the single most important factor. They link the source and the application. Linker is a term that Professors Creighton and Jolly use in their research. The literature shows other somewhat similar terms in use by various other research teams.

Credibility of the source is obviously an essential factor. Certainly if the "would-be" user does not believe the message he is getting, he will reject it. The information that is being transferred must therefore emanate from a source that is at least credible according to the perception of the recipient or the potential user. The *rewards* (and penalties) for the consequences of applying technology that is "new" to the receiving organization imposed by management are crucial. Namely, if a man is to get penalized more than rewarded, he will most certainly be disinclined to import a new piece of technology idea, or approach that which is "untried" within his particular organization.

Willingness simply is the fact that a man who is going to make use of a piece of technical information must be willing to receive the message and must be willing to implement it. It is that simple, and that subjective. Obviously a number of things could affect a man's willingness.

Of all the elements in the linker model, the *linker* element was chosen for study because it seemed to focus on people most directly. From other similar research reported in the literature, it was established that the human factor is probably the most important element in technology transfer.

The linker is associated with the source, or with the user, or he could be somewhere in between, or linkers could be at both ends (see Figure 1–6). Professors Creighton and Jolly (and the literature) are inclined to feel that the linker is more appropriately a member of the user team. I tend to place the linker in the middle because he is not an individual, he is the synergistic effect of all the people in the communicating chain from transmitter to receiver. All of these people in

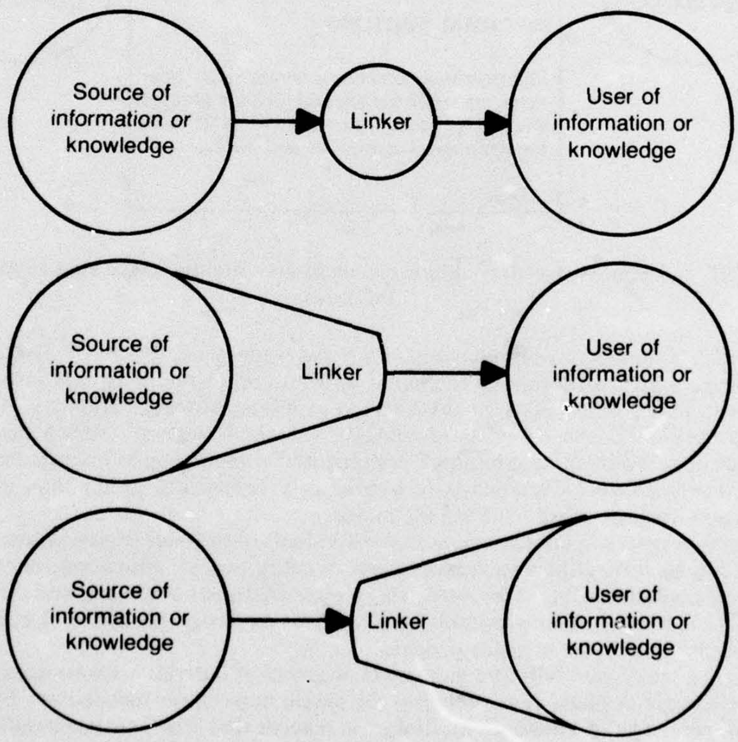

FIGURE 1–6 Linker Positions in the Flow of Knowledge

their respective contacts must link. Linkage occurs when mutual excitation between two individuals occurs because their values match at least for the particular technology transfer event. Indeed if the linker is at the user end and he enjoys the confidence of the would-be using team, he can operate internally in the organization to get the idea implemented or used.

At the beginning when I spoke of the chronology of NAVFAC's technology transfer efforts, I mentioned the establishment of the Field Engineering Support Office (FESO), in the Civil Engineering Laboratory. This was a conscious bureaucratic act to establish a visible, and at least a formal, linker at the Laboratory or the source. The establishment of Liaison Officers at the Engineering Field Divisions was similarly a conscious act to formally designate linkers at the Field Divisions, the user organizations. Whether these people are in fact effective linkers as the literature described linkers is a different matter; we don't know. Conceivably we could study them. The point is that these formally designated linker jobs were not necessarily filled with "linker type" people. The qualities of the linker are listed on Figure 1–7. At the time these jobs were filled there were very few, essentially intuitive, criteria in judging the potential linker attributes of the individuals selected for the Liaison and FESO positions. You all know the typical recruitment process we go through in the government. Furthermore, in filling these jobs, selection was limited to available people. In some cases there was no selection in terms of individuals, but rather only in terms of organizational convenience. In any case it is difficult to select people who will link. If you succeed, it is an accident as much as it is design.

INNOVATIVE, WILLING TO ACCEPT RISK, ACTIVE IN MULTI-DISCIPLINES, MORE INFORMATION CONTACTS, HIGH CREDIBILITY WITH PEERS, COSMOPOLITE, ORIENTED TOWARDS OUTSIDE INFORMATION SOURCES.

FIGURE 1–7 Attributes of Linkers

GREAT MAN (GLOCK AND MENZEL 1958)
SCIENTIFIC TROUBADOR (MENZEL 1964, HODGES AND NELSON 1965)
INTERNAL CONSULTANT (ALLEN et al 1968)
TECHNOLOGICAL GATE KEEPER (ALLEN 1966)
OPINION LEADER (LAZARSFELD 1948, KATZ 1957)

FIGURE 1–8 Writings on Aspects of the Linker Concept

The linker concept is not particularly original in that many authors have, in a sense, touched upon the notion of the linker from time to time in their works (see Figure 1–8). What is new in the work done at the Naval Postgraduate School is that all these terms and definitions are recognized as subsets within a universal linker set.

In order to get on with the job of approaching quantification of the linker model, it was decided to survey first the Navy's officer sector in charge of NAVFAC and its Field activities. This was done using a questionnaire (Appendix A) designed to measure whether a person in a given situation would be inclined to function as a linker or the opposite, a stabilizer. Would he be innovative? Would he be prone to accept the risks that would go with the acceptance and application of a new idea? Would he be a person with a high number of sources of information at his disposal? Would he be acquainted in many areas? We could not go around and interview 1,700 people, so we had to design a fairly clever questionnaire. The answer to any one question does not indicate that a man is a linker or a stabilizer.

It is the answers to a number of questions and combinations of questions that would cause us to categorize one man a linker, and another man a stabilizer. Initially we tried to determine who the linkers and stabilizers were among the Civil Engineer Corps Officers.* After seeing the distributions of the results, we wondered what the distribution of linkers versus stabilizers would be for civilians GS–8 and above. The results are shown in Figures 1–9, 1–10A and 1–10B. On the basis of the questionnaires and distributions between officers and civilians on the linker-stabilizer scale, we cannot say that civilians are more prone to be linkers than officers or the other way around.

1972 1726 NAVAL OFFICERS
(CIVIL ENGINEER CORPS ONLY)
(65% RESPONSE)

1973 2954/4464 GS-8 to GS-16 NAVFAC
CIVILIANS (54% RESPONSE)

.... NOT POSSIBLE TO DISTINGUISH BETWEEN THE TWO POPULATIONS (CLASSEN 1973)

.... THE LINKER-STABILIZER BEHAVIOR CHARACTERISTIC HAS A GENERAL BASE IN TERMS OF TECHNICALLY TRAINED PERSONNEL AND IS NOT UNIQUE TO A SELECT POPULATION

FIGURE 1–9 The Officers and Civilians Participating in the Linker-Stabilizer Survey

An examination of the data from these questionnaires reveals three questions the answers to which suggest that in some ways Naval Officers and civilians behave somewhat differently (Figure 1–11). Naval officers seem to attend fewer professional meetings and one can perhaps understand that because their mobility prevents their becoming established. They depend heavily on literature. For instance, when you are in charge of construction contracts one day, the next day you move into a design division, and two years later you move into a staff position, you are changing quite rapidly. Following literature rather than the professional community contacts becomes more logical and easier. On the other hand the civilian is more inclined to use his personal experience. The civilian tends to stay for a number of years, provides continuity in the organization and can draw from the problems he had several years ago in developing answers to new situations. Figure 1–11 shows that civilians tend to center interests with their fellow workers whereas officers more often center interests with people doing similar work.

I can only urge the interested reader to obtain a copy of the thesis and see the extent to which results of that work could be applied to your organization. It is emphatically stated that we did not do this survey or cross section in order that officers and civilians would be labeled as linkers or stabilizers and then keep them in or out of certain jobs. Although we know who the linkers and the stabilizers are, we do not know how to integrate that information with all the other do's and

*The Civil Engineering Corps is comprised of Naval Staff Officers primarily responsible for the construction and maintenance of Naval Shore Facilities world-wide.

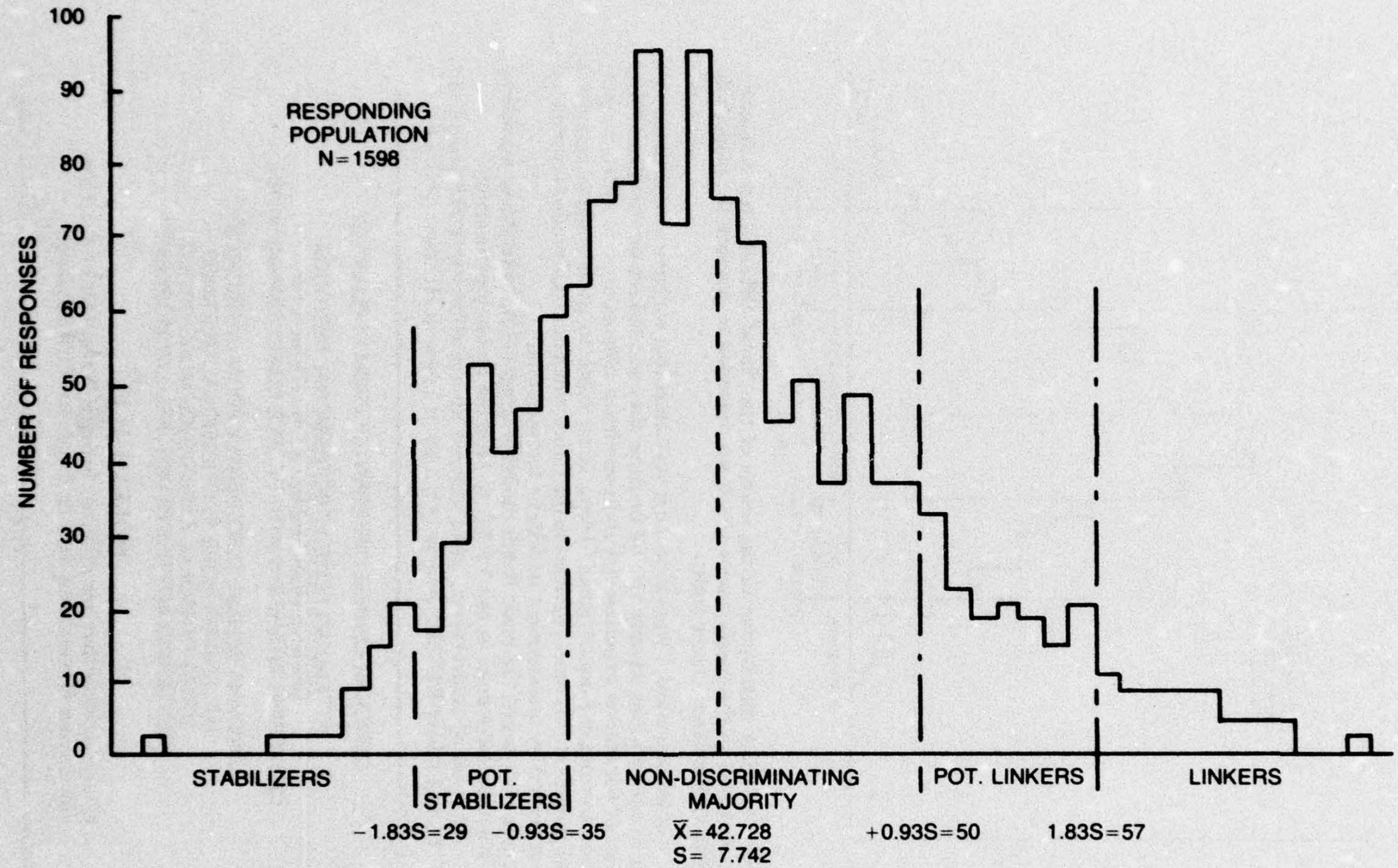

Figure 1–10A A distribution of the scores of the Government Service employees in response to the questionnaire which was intended to measure the magnitude of their stabilizer-linker traits.

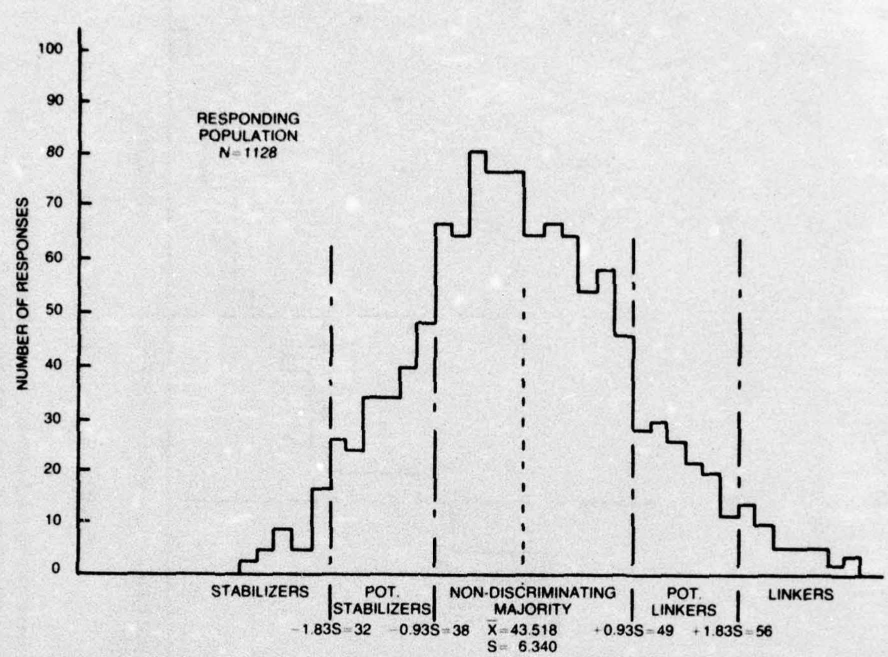

Figure 1–10B A distribution of the scores of the Naval Officer Civil Engineers in response to the questionnaire which was intended to measure the magnitude of their Stabilizer-Linker traits.

don'ts of job selection. I want to make it very clear that we have no designs at this time to start shifting people around because they are linkers or stabilizers. The nature of the data is experimental and complex problems arise in satisfying personnel and organizational goals. There is no basis to even suggest personnel reassignment at this time—perhaps in the future when our total study is completed and accepted by management as a basis for selection.

I have rearranged the basic linker model (Figure 1–12), to facilitate my telling you what we have done in NAVFAC to promote technology transfer:

1. *Selection of projects*—we have stepped up our efforts to make use of our Field Liaison RDT&E people in letting us know in Headquarters what the

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OFFICERS BEHAVE DIFFERENTLY FROM CIVILIANS BY:

ATTENDING FEWER PROFESSIONAL MEETINGS
DEPEND MORE HEAVILY ON LITERATURE
CENTERING INTERESTS WITH PEOPLE DOING SIMILAR WORK

CIVILIANS BEHAVE DIFFERENTLY FROM OFFICERS BY:
ATTENDING MORE PROFESSIONAL MEETINGS
USING PERSONAL EXPERIENCE MORE OFTEN
CENTERING INTERESTS WITH FELLOW WORKERS

FIGURE 1–11

Characteristics that are different between Naval Officer Civil Engineers and Government Service Employee Civil Engineers

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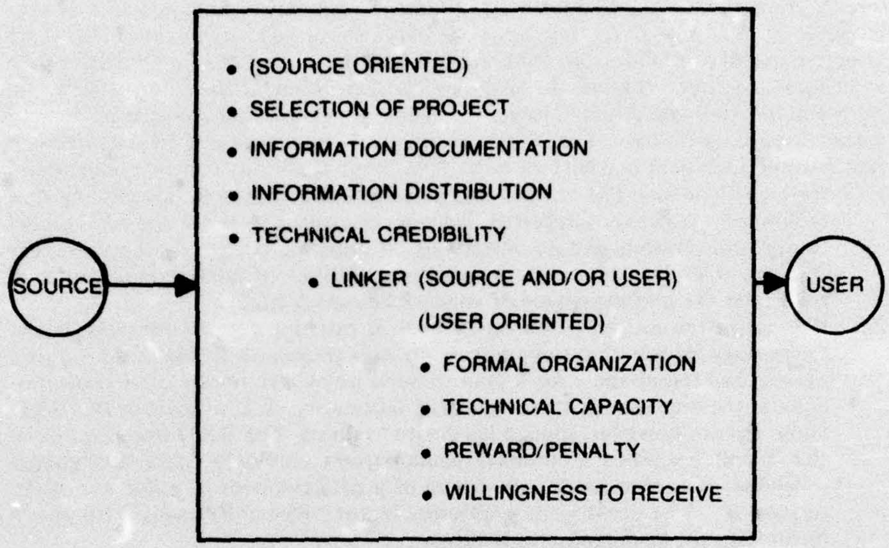

FIGURE 1–12 Activities Applied to the Basic Linker Model

field perceived R&D needs are, and what research projects they want funded.

2. *Information documentation*—in addition to technical reports the laboratory now puts out several additional types of publications that are readable and more responsive to the non-research practicing engineer and maintenance personnel. These are one or two page briefs of significant technical accomplishments (Tech Data Sheets) and periodic status reporting of work still in progress. (RAP Briefs). Also pictorial-graphic brochures are more widely used. Communication awareness seems to be spreading among researchers and management at last!
3. *Information distribution*—Distribution lists tend to go out of date quite rapidly and must be constantly maintained. An organization can be saturated with a lot of literature that is not needed for its particular mission. Economizing by avoiding the fine tuning of distribution lists for specific technological output tends to prevent effective distribution. Attempting to keep distribution lists up to date is a continuing job. Distribution is also directed to individuals and not merely to "desks".
4. *Technical credibility*—Frankly, we do not have a very good way of knowing whether recent technology transfer activities have caused the technical credibility of our laboratory, as perceived by the man in the field, to go up or down. I could speculate and say, "yes, I think it has gone up." When I do this I am not being true to empiricism and the purpose of having NPS do research on our research. We want to generate a certain amount of hard data in order that management can get a better understanding of our particular technology transfer processes as a basis for policy and action. Without credible facts, neither Headquarters nor laboratory management can take action towards greater user credibility of the laboratory. Perhaps we need a survey of opinions from time to time to track credibility of the laboratory.

I mentioned the *linkers* at some length. We have done studies with the assistance of the Naval Postgraduate School to try to improve our understanding of our

formal organization and to determine whether it impedes or enhances the flow of technology. In regards to the *technical capacity* of our organization to make effective use of our laboratory generated technology, I do not think we have data as of now to tell you that we do or do not have it. Some of the future studies by NPS will hopefully be directed towards a measure of technical capacity as defined earlier. Again, intuitively, I believe over the years the output of CEL has become tuned to the technical capacity of NAVFAC, but again this can be contested.

1. *Reward/Penalty*—The reward and penalty associated with introducing new technology, however important, has not been studied, measured or assessed in our organization. Again, intuitively, it appears to me that there is more concern over the consequences and probabilities of failure (however low) than over the consequences of success (however high).
2. *Willingness to receive*—We have made it possible for anyone who needs technology information to be physically able to receive it. Means exist, i.e., money and telephones, for a man in need anywhere in our organization to consult the engineer or scientist at the laboratory. We, at least in the R&D shop, cannot however, induce his desire to do so. The R&D organization at the Naval Facilities Command headquarters can only make technology available. It cannot induce the desire of a field engineer to make use of the technology. The previously mentioned factor "Reward/Penalty" has much to do with the willingness to receive.

In closing, let me just say that our efforts are continuing and we hope that in the years to come we can develop some significant body of hard data that can serve as a concrete basis for management selection to improve the technology transfer environment throughout. Also we hope that our research results can be of value to other government and industrial organizations.

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2. SUMMARY AND VALUE OF TECHNOLOGY TRANSFER PROGRAMS AT THE NAVAL FACILITIES ENGINEERING COMMAND

by

V. M. Skrinak

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I see by the roster that most of you are from the R&D community. I am new to the R&D field only having been involved for about a year now. I would like to submit to you that the people outside of the R&D community are doing a lot of complaining. I suggest if you stop and think about it a minute, it can be traced directly to technology transfer, because unitl you get that product into the hands of the field engineers and they can use it, they are incensed because you are working on what you want to work on, not what the field sees as vital to their present needs—you are not working on their problems. So from an operator's standpoint this is what we have to overcome, and it is going to be a long time in overcoming. It will take real effort.

So with that I would like to summarize what you have heard this morning. First of all, I think the thread that ties this all together was Milon Essoglou's pitch on the Linker Study. What is the methodology—the mechanism—whereby we can transfer our technology? I think this is very important and I will refer back to it again and again as it is the cornerstone, the building block, on which we have to evaluate technology transfer. Also as you have heard in our past experience here, the RDT&E Liaison Engineers were set up before we had the linker study, but once we had the linker study we found out that very fortunately we had fallen into a number of good things. We set up the Liaison Engineer so we would have a "gatekeeper"—one who would take in the technology to our Field Divisions and disseminate it to our engineers. We also had another purpose which we found very valuable, and that as he was collecting the problems and feeding them back to the laboratory, we got the field engineers to have a feeling of relevance to R&D when we did work on their particular projects. We have that relationship which was referred to in the linker study. Early involvement in project selection is important. We then have these relationships with the linker study and its analysis of technology transfer mechanisms.

In RDT&E Assistance, we have a response to the field, and I refer back to the linker study. Until we can get credibility in the field and until they know we are working on their problems, we are going to have a barrier to our technology transfer. RDT&E Assistance is one small part of that, where we can respond to the field's needs and try to get our credibility established again in their eyes with a resultant willingness on their part to more readily accept R&D technology coming out of our Laboratory.

The Techdata Sheets and RAP Briefs were alluded to very briefly this morning—but what we have done here is to try to get a very high impact and an immediate feedback to the field. One that hits you between the eyes. You get it on a single sheet, not a report about 25 pages long with double and triple integrations which when the normal man in the field looks at it says that's no good to me and throws it away. The bottom line on these reports may be of extreme value, be it corrosion studies, be it maintenance reduction, or whatever it is. We have Techdata Sheets and RAP Briefs that are intended to have a high impact. Are you interested? If so, this has all the information you are looking for and who to call for more information. We are getting the distribution and the documentation to the field in the best way we know at this time in order to get the maximum amount of technology transfer.

These are the efforts then that we have had in the past (See Figure 2-1). What do we have right now (see Figure 2-2)? We had a complete analysis of our program—where is it paying, the cost benefits, in what categories, where are the most benefits coming from with regard to callers, with regard to stations, with regard to geographical areas? So we have an analysis in this area to look at and possibly assist us in emphasizing our technology transfer efforts to improve its impact.

NAVFAC TECHNOLOGY TRANSFER

PAST

LINKER STUDY
RDT&E LIAISON ENGINEER (EFD)
RDT&E ASSISTANCE
TECH DATA SHEETS
RAP BRIEFS

FIGURE 2–1 Listed here are the various steps that have been taken to improve the NAVFAC Technology Transfer effectiveness.

NAVFAC TECHNOLOGY TRANSFER

PRESENT

RDT&E ASSISTANCE PAYBACK
FACILITATORS TO TECH TRANSFER

FIGURE 2–2 The current work is directed toward determining the ROI of RDT&E Assistance and to study the Facilitators to Technology Transfer.

I put facilitators in Figure 2–2 as opposed to barriers. You can put it any way you like. This afternoon Dr. Jolly will be talking about a comparison of Navy organizations with civilian organizations. Are there similarities? Are they different and if different why? What we are looking at then is how can we compare ourselves with civilian institutions and on-going efforts.

I think the most important aspect then is what do we see coming out in the future (See Figure 2–3). Again, as a spin-off from the technology transfer efforts of Professor Creighton and Professor Jolly, we have asked, and they have come up with, a course—a short course. We are not talking about anything new, really, in this course. You all have applied the principles that were discussed this morning on the linker study, but it is a matter now of getting technology transfer for our technology. The only way we can get it to the field is to get out there and let the people know what we are doing, what are the barriers, what are the facilitators of technology transfer, and try to open up some of the minds that are there in our Engineering Field Divisions and at Headquarters.

NAVFAC TECHNOLOGY TRANSFER

FUTURE

SHORT COURSE ON TECH TRANSFER
ROI
DEFINITION OF CLASSES OF SUCCESS
STANDARDS OF ACCOMPLISHMENT

FIGURE 2–3 Listed here are several of the projects that are planned for the future. As before the objective is to improve the NAVFAC Technology Transfer effectiveness.

We are very optimistic and hope that this will pay some dividends back, but again we hope to have the first course shortly and get this information out to all of our engineers and scientists.

Return on investment—this is under the gun more and more. What is your return on R&D? We would like very much to get a handle on just what we are talking about here. Definitions are critical in this area. Two come to mind immediately in evaluating return on investment—the definition of classes of success and standards of accomplishment. We can write a report and it might be a very good report and it might sit on that shelf for 10 years before it is needed. Well, was

it successful? Let us define what we mean by success. I think there are many different categories here, so I think those have to be defined and classified.

What should we be shooting for at the Civil Engineering Laboratory in the way of technology transfer and our results? Not only that, but we have to define, as you saw in the linker study, two things. There is no way we can hold the Civil Engineering Laboratory responsible for what ultimately ends up as being transferred to the field. Why? Because there is another guy locked in the middle there. Now the laboratory can be responsible for what is source oriented—they generated it and that generates, if you will allow me to quote an author, "opportunities to exploit", but then the users of that must take those opportunities and actually put them to use. And I think here we have to define our terms so that we can look at the Laboratory and determine how they are doing and how others are doing in exploiting opportunities. One of you may be doing well, or both may be doing well but we have to have a refined classification in order to evaluate our standards of accomplishment.

Those are the areas then that I look for in our continued involvement with technology transfer.

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3. A CASE STUDY OF THE POWER LINE DISTURBANCE MONITOR

by

E. Harry Tempest
L. Arthur Van Rooy, Jr.

Commander and Lieutenant Commander, respectively, Supply Corps, United States Navy

Introduction

Congress has authorized the Department of Defense (DOD) to spend a record $9.3 billion this year on military research, development, test and evaluation (RDT&E). (Ref. 1). Does this mean that taxpayers are investing *only* in research for an arms race that may ultimately end in nuclear holocaust?

Not so! In addition to providing for a strong future national defense, a substantial portion of military research and development expenditures are quietly financing new technology that will contribute to the progress of civilian society, perhaps even to its survival. Military advances in areas such as medical research, environmental protection, and air traffic control, just to mention a few, are also products of defense RDT&E spending and deserve equal billing as they are successfully transferred from military to civilian application in order to solve society's mounting problems.

Criticism Levied at DOD R&D

In recent years, critics have posed questions such as: "Why can't DOD develop a technology utilization program such as NASA did during the peak years of the space program? Look at the spin-off benefits that accrued to all Americans, even the entire world, from that program!"

Criticism of this nature is certainly legitimate and was recognized by the President when he stated,

> "As we face the new challenges of the 1970's we can draw upon a great reservoir of scientific and technological information and skill—the results of the enormous investments which both the Federal Government and private enterprise made in research and development in recent years . . . we must appreciate that the progress we seek requires a new partnership in science and technology—one which brings together the Federal Government, private enterprise, state and local governments, and our universities and research centers in a coordinated, cooperative effort to serve the national interest . . ." (Ref. 2).

In response to the President's policy statement, several DOD R&D laboratories joined together in July 1971 to form the DOD Technology Transfer Consortium, the purpose of which is "the transfer of existing knowledge, facilities, or capabilities acquired while working on military research and development projects, to the solution of civil problems." (Ref. 3). Spurred by the knowledge that military research funds expended by DOD can also benefit other segments of our society, the consortium has grown from eleven to thirty-one Army, Navy, and Air Force laboratories. (Ref. 4). In November, 1974, membership was extended to all government laboratories and the Federal Technology Transfer Consortium was formed.

The Navy's Technology Transfer Program

The Navy, whose share of the fiscal year 1975 DOD RDT&E budget totaled $3.5 billion, has been a strong advocate of technology transfer for many years. There are thirty-seven Navy activities involved in research and development throughout the United States, each with a specific research and development mission. (Ref. 5). Because the Navy-Marine Corps team operates in all of the earth's environments—at sea, underwater, and on land—Navy laboratories have been responsible for the development of new and advanced technology in many different areas of engineering and science. The Navy has traditionally been a close partner with university and commercial ocean-oriented research, and has

always felt an obligation to share its achievements with these other organizations. Consequently, the Navy was the first military service to issue an implementing instruction calling for an active technology transfer program within the Navy, and requiring the designation of a person as a contact for technology transfer in the various laboratories and components of the Navy under the Naval Material Command. The instruction also calls for an annual report of progress. (Ref. 6).

Although technology derived from Navy R&D has been applied successfully to a wide variety of civilian problems since the inception of the technology transfer program, the efforts of one Navy laboratory, in particular, have been an outstanding success. This paper will describe their technology transfer program and trace the development of one product which is now available commercially and is being used by more than 100 organizations and businesses, both in the public and private sectors, throughout the United States and abroad.

Navy's Civil Engineering Laboratory

The Navy's Civil Engineering Laboratory (CEL) located adjacent to the Pacific Ocean in Port Hueneme, California provides a stimulating background for creativity and technological advances. Port Hueneme means "pleasant place" and it is not surprising that the location, just 60 miles west of Los Angeles with its huge industrial complex, attracts the most qualified scientific and technical achievers. The work of the laboratory covers a broad field of technology, going well beyond the scope of civil engineering. The laboratory, operating on an annual budget of $12 million, is the principal RDT&E center for shore and sea-floor activities, and for the support of Navy and Marine Corps construction forces. The laboratory's workload includes programs in electronics, sanitary engineering and mathematics, as well as physics, chemistry and allied sciences.

The staff at CEL numbers approximately 310, more than half of whom are professional engineers and scientists. Master and Doctorate degrees outnumber Bachelor degrees by more than three to one. The laboratory is headed by a military Officer-in-Charge with a solid engineering background and a Technical Director who is a senior Civil Service scientist. The majority of the research personnel are Navy Civil Service employees. A job rotation program that allows the individual to select his own special area of interest, an engineering-in-training program, and rapid advancement are features of the CEL working environment. The comment of one scientist at CEL is indicative of the feelings of most of the laboratory's employees; "In this age of giant strides in space, the undersea world, in nearly every branch of industry, the challenge is the thing that keeps us alive and awake. Beating the challenge is the thing that gives us real job satisfaction. Without it, life would be pretty dull."

Technology Transfer at CEL

CEL has actively promoted technology transfer for many years and is responsible for a host of Navy R&D spin-off items that are benefiting society in the fields of environmental protection and energy conservation. New developments have found their way into the private sector and are stimulating corporate growth in a period when an economic stimulus is most welcome. CEL possesses a wide variety of technical expertise. To further indicate the diversity of ongoing work, the laboratory is involved in the establishment of polar bases on snow and sea ice, deep ocean systems, floating naval bases, waterfront structures, power transient detection and correction, even a skull/brain injury computer program. The success of CEL's technology transfer is attributed to the organization's progressive attitude which is symbolized by the laboratory's motto—"find a way . . . or make one."

Recognizing the importance of technology transfer, in 1972 the laboratory established a technology transfer program. The theme of the program centered around the following command statement:

> Implementation of the results of successful work units is perhaps the best measure of the Command's success in fulfilling mission requirements. We must therefore strive at all times for the increased utilization of our research results by the Department of Defense, the Navy, the Navy Facilities Engineering Command, and the entire scientific and technical community. We must also manage the utilization of technology on an objective and systematic basis.

CEL's technology utilization efforts were directed at all appropriate parts of the Navy and addressed its total mission and commitments. The thrust of the program was to close the gap between CEL developed technology and acceptance and application by a wide spectrum of Navy users. It was apparent to CEL that if their created technology was going to sell itself beyond the primary recipient, then a marketing plan was also an essential ingredient. Foremost, the program must be user oriented and involve people in both ends of the spectrum. "CEL is going to push . . . we must involve the user so he can help pull when we push." The command's formulated technology transfer program contained the following elements:

1. Identify underutilized CEL developed technology.
2. Identify new users and benefits to be gained by them.
3. Select candidates for marketing.
4. Assign internal CEL responsibility by product.
5. Develop background information.
6. Approve/modify marketing strategy.
7. Perform an economic analysis.
8. Develop a marketing plan.
9. Market product (advertise).
10. Evaluate progress.
11. Publicize success or recycle if not successful.

Recognizing the fact that increased utilization of technology was synonymous with increased communication between CEL and potential users, various forms of communication were evaluated and measured for effectiveness in achieving the program's objectives. After finalizing all aspects of the newly developed technology transfer program, CEL's Assistant Officer-in-Charge concluded, "Our utilization efforts are experimental. We really don't know how to promote utilization nor does anyone else. We have some ideas that we'll try and we'll learn in the process. We're talking about promoting change—aggressively promoting change to a better way of doing things."

With the foundation of the program laid, CEL's next step was to choose candidates from newly developed products that were considered to be under-utilized but with a high potential for beneficial application within the Navy. The selection included a cathodic protection kit for ship moorings, a weathered paint identification kit, cathodic protection system for water tanks, diver tool kits, a single line heat-traced pipe system, quick camp modules, funicular shell construction, and a three-phase electric power line monitor. The development, marketing and impact of the power line monitor on the public and private sectors as a result of CEL's aggressive technology transfer program serves as an example of the total benefits to be gained from Navy research and development.

CEL's Investigation of High Quality Electric Power

During the latter months of 1963, well before any public concern was expressed over a possible fuel shortage and its resultant effects on electrical power output, CEL initiated a research project to determine the requirements for high quality electric power for sensitive electronic equipment in use at Naval shore stations.

The Navy is a heavy user of electrical power in a variety of shore stations containing technical loads related to command and control, communications, computer and navigation functions in support of the Navy mission. Operational reliability of sensitive equipment constituting technical loads is directly affected by the quality and reliability of power. This power is presently supplied with a wide range of quality and reliability. At the time of the CEL study, few if any satisfactory procedures or techniques existed which would provide for cost effective compatibility between the quality of supplied power and the power requirements of critical, sensitive equipment.

Development of Power Line Monitor

During CEL's investigation into the quality and reliability of electrical power at Naval shore stations, it became readily apparent that some means of monitoring and categorizing transient disturbances in power supplies that caused operational malfunctions and damage to critical equipment would be required.

An industry-wide search was conducted to determine if a suitable and economical power line monitor was commercially available. Numerous monitors were found, but most of them were designed to monitor a few specific parameters. Their costs ranged from approximately $300, for a unit that could monitor a single parameter, to elaborate power line monitoring systems costing as much as $25,000 with still only a three parameter capability. There was also the problem of portability. Since many Naval shore installations are located in remote areas, both in the United States and overseas, a several hundred pound monitoring system would not be suitable for shipment to, or use in the field. This led to the CEL development of a prototype, portable, low cost, three-phase power disturbance monitor.

By May 1972, the first prototype monitor had been designed, fabricated, and tested by Mr. M. N. Smith, one of the civilian employees of Civil Engineering Laboratory. It was capable of detecting, categorizing, and counting the occurrences of anomalies in electrical power systems. The monitor could detect power disturbances in all three phases, line-to-neutral voltages without the necessity of differentiating the phase in which the disturbances occurred. It could continuously monitor pulse transients and variations in voltage and frequency which exceeded pre-selected levels. Whenever a preselected level had been exceeded, a single count was registered in one of five counters which categorized the disturbances as an under-voltage, an over-voltage, an under/over frequency, a low magnitude impulse or a high magnitude impulse. Even a combination of disturbances occurring simultaneously could be properly categorized and counted. The monitor contained visual warning lights, an audio alarm, and an AC volt meter. (Ref. 7). The original prototype monitor was housed in a 22×14¾×10¾ inch cabinet and weighed only 48 pounds (See Figure 3–1).

The total R&D funds associated directly with the development of the original prototype power line monitor have been estimated at $10,000. (Ref. 8). The successful completion of this project coincided with the implementation of the laboratory's technology transfer program. After the original prototype monitor had been successfully bench-tested at the Civil Engineering Laboratory, the decision was made by the Naval Communications Command to procure six additional monitors for field-testing and utilization at various Navy shore installations. In March 1972,

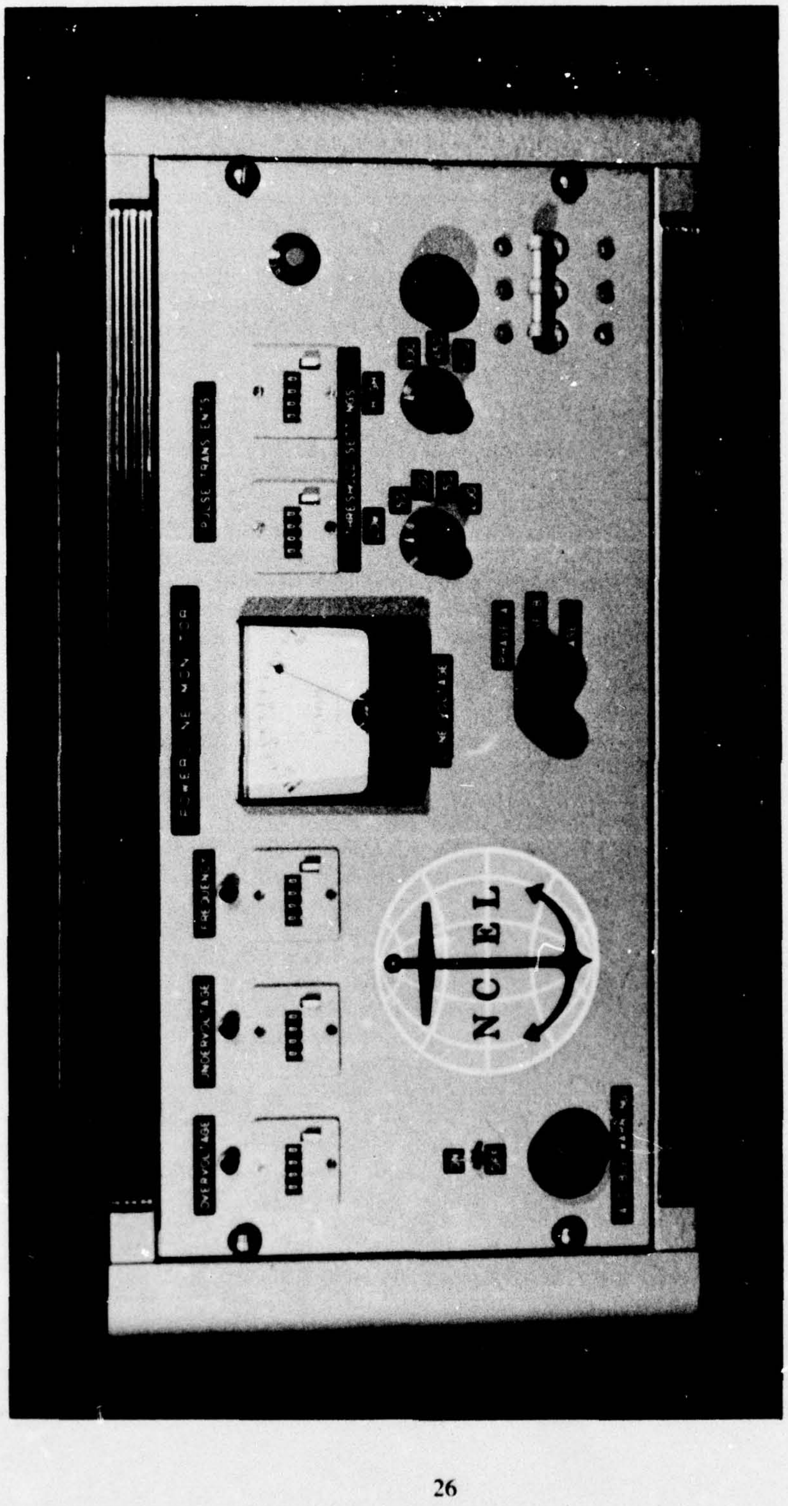


Figure 3–1

a Request for Proposal to design, fabricate, deliver, and test the six new monitors was submitted to the U.S. Department of Commerce for publication in the "Commerce Business Daily." The successful bidder would be required to meet CEL's specifications for the monitor.

Programmed Power Inc., a small electronics manufacturing subsidiary of Franklin Electric Company, decided to submit a proposal and bid for the contract. The company had recently started operations in Menlo Park, California and had undertaken an extensive research and development project in the field of uninterruptible power systems. They had also performed some preliminary R&D on power line monitors, with the thought of possibly marketing them in the future. Programmed Power was the successful bidder, and in June 1972, received the contract for six monitors. The contract called for delivery of the units by September of that year, and for the performance testing to be conducted at the Civil Engineering Laboratory during October. The total amount of the contract was $22,479, or $3,749.50 for each of the six supplied monitors.

Transferring the Technology of the Monitor

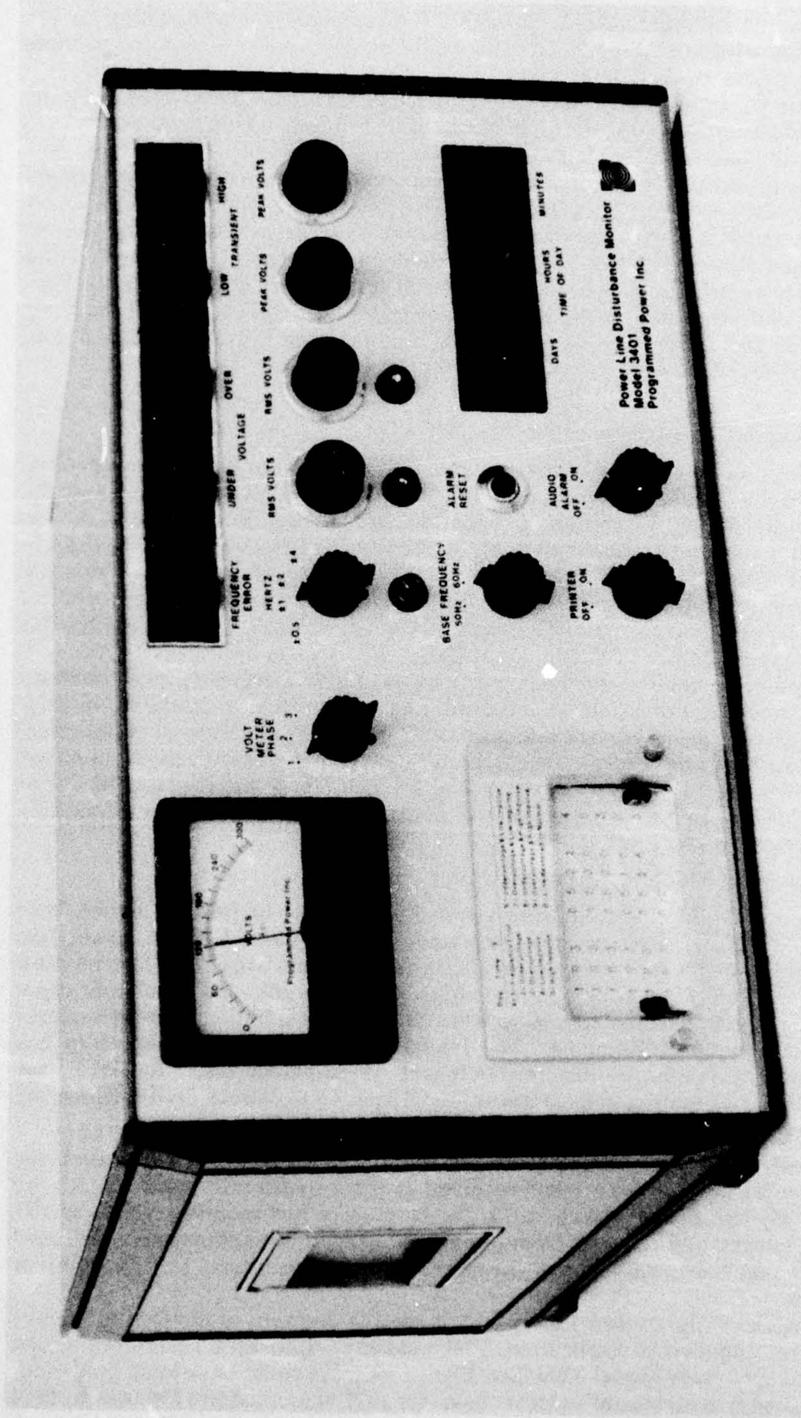
While waiting for delivery of the new monitors from Programmed Power, CEL field-tested the original prototype at the Naval Station, Rota, Spain, and the Naval Coastal Systems Laboratory, Panama City, Florida. Both field evaluations were totally successful. Realizing that the monitor had potential widespread application for the Navy, CEL issued a complete technical note, describing the monitor and its capabilities in June 1972. The initial distribution of the technical note was to all Naval Facilities Engineering Command activities and the Defense Documentation Center in Washington, D.C.

Based upon the enthusiastic response from the Navy civil engineering community, CEL made the decision to make the monitor a primary candidate in their technology transfer program. In August, 1972, a press release was sent out offering to make the results of the research and development efforts on the monitor available for use by private industry. The following note appeared in the "Engineering News Letter" section of the September 11, 1972 edition of ELECTRONICS MAGAZINE:

> Power Line Monitor From the Navy
>
> *Tired of wondering what your power line is doing, or for that matter, isn't doing? If so, you may be interested in a low-cost, 3-phase power line monitor that keeps an eye on the output of such supplies. The monitor checks for both over and under-voltage and frequency, and positive or negative pulse transients from 50 to 600 volts of pulse duration of from 1 microsecond to 16 milliseconds. The Naval Civil Engineering Laboratory has made the results of this research and development effort available; for further information write: Utilization Officer, LO2, Naval Civil Engineering Laboratory, Port Hueneme, Calif. 93403.*

The response to that magazine article was overwhelming. Within a week the Civil Engineering Laboratory had received 71 requests for information about the monitor. By the end of March, 1973, the laboratory had received a total of 177 separate information requests from private industry, other military services, governmental agencies, universities, hospitals, 36 state agencies, and 14 different countries.

Meanwhile, Programmed Power Inc. made the decision to develop a monitor suitable for commercial application. The company improved CEL's basic design and introduced their Model 3200 (See Figure 3–2). As could have been predicted, their product was an instant success. Sales for 1973 amounted to $196,000. In 1974



FREQUENCY ERROR
UNDER VOLTAGE OVER
LOW TRANSIENT HIGH
RMS VOLTS
RMS VOLTS
PEAK VOLTS
PEAK VOLTS
HERTZ
BASE FREQUENCY 50Hz 60Hz
ALARM RESET
AUDIO ALARM OFF ON
PRINTER OFF ON
DAYS HOURS MINUTES
TIME OF DAY
Power Line Disturbance Monitor
Model 3401
Programmed Power Inc
VOLT METER PHASE
1 2 3
VOLTS
Programmed Power Inc

Figure 3–2

Programmed Power Inc.

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12/3/74

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Bowling Green State University
Brookhaven National Laboratory
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Burroughs Corporation
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Canadian Bank of Commerce
Canteen Corporation
Chandler Leasing Corporation
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E C R M
Electro Rents
Elektro Ziegler (Germany)
Empresa Brasileira de Telecommunicacoes, S.A.
Emery Air Freight
Ford Motor Company
Four-Phase Systems Inc.
GTE/Information Systems
GTE/Lenkurt Electric
General Motors Properties
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Hercules, Inc.
Hewlett Packard
Hoffman-LaRoche
Honeywell Inc.
Houghes Aircraft
IBM
Identicon
Industrial Nucleonics
Kitchens of Sara Lee
Eli Lilly & Company
McDonnell-Douglas
Medical Center Company
Metropolitan Life Insurance
Ministerio da Fazenda, S.A.
State of Minnesota ISD
Montgomery Ward
NASA—Ames Research Center
NASA—Johnson Space Center
NASA—Langley Research Center
NASA— Marshall Space Flight Center
National Accelerator Laboratory
National Bureau of Standards
National Institutes of Health
New York City Off-Track Betting Corp.
New York Telephone
New York Times
Pacific Northwest Bell
Palm Beach City Data Processing
Palos Community Hospital
Philco-Ford Corporation
Portland General Electric
Pratt & Whitney Aircraft
Privy Council of Canada
PRD Electronics
Randolph Engineering
Rental Electronics
Rich Inc.
St. Regis Paper Company
Scan Data Corporation
Port of Seattle
A. O. Smith Company
Stanford Research Institute
Stanford University
Summit Radio Corporation
Teledyne-Inet
Teleswitcher Corporation
Texaco, Inc.
Texas Instruments
Thatcher Glass Manufacturing
Tymshare, Inc.
Union Carbide Corporation
U.S. Air Force Academy
U.S. Army, Anniston Depot
U.S. Army, Ft. Huachuca
U.S. Army, MERDC
U.S. Army, Red River Depot
U.S. Army Security Agency
U.S. Defense Electronics Supply Ctr. (Pt. Mugu Air Station)
U.S. Navy Air Station North Island
U.S. Navy Civil Engineering Laboratory
U.S. Navy Puget Sound Shipyard
U.S. Navy Subic Bay Torpedo Station
U.S. Navy, WesNavFacEngCom
U.S. Department of Commerce (NESS)
U.S. Department of the Interior (Bureau of Mines)
U.S. Department of State
Univac
University of Michigan
Wellsco Data Corporation
Western Electric
Westinghouse Electric
Wisconsin Electric
Xerox Palo Alto Research Center

Figure 3–3

sales of the monitor totaled $454,000 and the 1975 sales forecast predicts close to $1 million. Programmed Power now offers a complete range of monitors to both the domestic and international markets (See figure 3–3). The company currently employs fifteen people, six directly as a result of the monitor. By 1978, when Programmed Power expects to enter the uninterruptible power systems market on a fairly large scale, employment is expected to reach 110 people.

Benefits Derived from Transferred Technology of the Monitor

The economic benefits of CEL's transfer of the monitor technology to Programmed Power Inc. are obvious and the company acknowledges that CEL was responsible for its entry into monitor production. (Ref. 9). Power line monitors have constituted the bulk of the company's business since its formation and is responsible for its growing work force.

The positive impact that CEL's transfer of the monitor technology will have on the country's economy as a whole can also be estimated. Utilizing the economic concept of the multiplier effect, it can be shown that a $10,000 research and development effort by the Navy will have led to the creation of an estimated $1,650,000 worth of additional goods and services by the end of 1975. If the Navy's R&D expenditure is considered to be the "initial investment," then the resultant "multiplier" will have been 165—an excellent return by any measure, particularly in these days of economic uncertainty. (Ref. 10).

The direct savings to the Federal Government users of the monitor as a result of its being commercially available are significant. The original six power line monitors purchased by the Civil Engineering Laboratory cost $3,749.50 each. The price of the same monitors fell to $2,995 when Programmed Power Inc. went into full-scale commercial production. Since then, the military services and other Federal Agencies have purchased approximately 35 of the monitors. If a conservative cost savings figure of $600 per unit is used, more than twice the initial $10,000 R&D costs have been realized to date.

Although CEL's development of a low cost, versatile power line monitor was initiated to fulfill a Navy need created by varying quality of world-wide electrical power supplies, the current fuel shortage and related energy crisis in the United States have increased industry's demand for power monitoring devices. The power-generating problem with its feared consequences of power outages, brownouts, voltage dips, transients, and frequency variations is worrying industry and rightfully so. According to Mr. Lee Cooper, President of Programmed Power Inc., "Last year's fuel and energy crunch woke up a lot of people in the electronics and computer industries. They found out that much to their dismay, they can no longer take for granted what comes out of that electrical socket in the wall." (Ref. 11).

In a recent article by Mr. C. P. Tsung, a highly qualified expert in electrical power consumption, the author states, "Brownouts will be a fact of life for an indefinite period of time to come." Mr. Tsung further reports that from a recent survey concerning the effects of voltage reductions, it was discovered that during brownouts, poor and unreliable operations were experienced with elevators and their controls, monitoring equipment, escalators, communication equipment, air conditioning equipment, and a wide variety of motors, computers, and other business machines. Particularly sensitive equipment, such as electronic data processing computers, production controls, and medical diagnostic instruments, are affected by even slight voltage variations, and probably should be removed from service when supply voltages do not range within specified requirements. (Ref. 12). Imagine the expense involved when a technician spends hours attempting to debug a computer malfunction when the culprit was not the machine but the

power supply; or the consternation of an executive making crucial corporate decisions on computer generated data that may be erroneous; or a doctor's fear that critical medical monitoring instruments may malfunction because of power problems. The monitor can detect and/or indicate solutions for many of these problems.

Conclusion

The power line monitor is just one example of how Navy R&D efforts, combined with an aggressive technology transfer program such as that at the Navy's Civil Engineering Laboratory, are benefiting society and returning public dividends from defense research dollars.

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4. APPLICATION RESEARCH EFFECTS IN THE FOREST SERVICE

by

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The research application effort in the Forest Service was started some 75 years ago. Somehow from the 20s to 1972 we lost sight of the fact that we had the responsibility of getting our research applied. Somewhere in that period we started talking to libraries and peers rather than user groups. Back in about 1972 the General Accounting Office did an audit of Forest Service research and as it came out it looked as if we were not getting any research applied. Therefore renewed effort was begun to get the research applied. From then on we had the challenge to see that the information from the Forest Service Research was moved out of the laboratories and journals and into the hands of the people who need it to help them solve problems.

The initial effort was to hire the CRUSK group to look at the Forest Service apparatus. The next step was to formulate a Washington Office Steering Committee. The committee was made up of the three branches of the Forest Service which are Research, State and Private Forestry, and National Forest Systems. In 1972 this committee originated a national workshop on Research Implementation which was conducted in Atlanta, Georgia. As a result of this research implementation workshop they looked at several problems within the administration of research, and within the administration of the Forest Service in particular, in regard to application research findings. They came up with about 28 recommendations—most of which have been put into effect. This was a week long workshop. Over 100 people attended. Most of the attendees were from the Forest Service. Some of the findings of the workshop resulted in a new chapter to the Forest Service Manual and Handbook which now covers the policies and service-wide responsibilities for research implementation. For the first time it sets out that there will be field responsibilities for research implementation and coordination. The Forest Service is also revising its research program section to cover responsibilities, roles, and implementation of research results. We organized a Washington Office Task Force to develop a uniform service-wide publication system because we realized fully that one of the important means of communications is through a publication process. This task force has submitted a draft report to the Chief of Staff.

Also in 1973 a National Research Information Service Advisory position to the Deputy Chief of Research was established. I became that. I was at that time working with the Northeastern Forest Experiment Station on information services work and I had a one-half responsibility for this national assignment.

My responsibility at the Northeast Station was to stimulate special activities that would lead toward better or more rapid application of research findings. This responsibility led to the development of a pilot project on packaging research for specific audiences. The success of this endeavor has generated interest in the packaging process for research applications. We were able to take a bit of research that one of our scientists had on decay and discoloration of trees and by unique packaging through illustration, simple slide presentations, we were able to get the message out far beyond where he had been able to reach with 100 technical publications. As a result of that we were given a responsibility to develop a national guide that other scientists could utilize in packaging their research. This guide is now available.

Each of the eight regional stations has an editorial and publication branch. But out in the regions and areas (there are two areas of the Forest Service and ten regions) there is no one responsible for taking the research information and putting it into language that the user can understand and use.

We have taken a series of publications which were originally entitled "What's New in Research in the West" and expanded that to "What's New in Research". It covered about four stations to explain what was happening at those stations so that a practitioner could understand it. If he wants additional information he

knows where to go to get it. We have a similar publication "Forest Research News for the South" which covers two areas.

Our research administration in the Washington office has been working with personnel to amplify and clarify the research grade evaluation guide to provide recognition to implementation efforts by scientists. We are trying to tackle the reward system.

The Chief and staff are working with the Extension Service to establish joint locations of extension foresters and Forest Service specialists at research centers and land grant universities, whenever feasible, on a person-to-person basis for the transfer of research information.

We have reorganized our experiment stations and for the first time we have a position which has direct responsibility for research implementation. We call it an Assistant Director (AD) for program planning and application. He is a key staff officer in the station. We had a workshop for these ADs for planning and application in February of this year, at which we established their orientation and major objectives by which they would tackle the application process. We have developed a Forestry Technical Information System working with the Atomic Energy Commission in Oak Ridge. We are going to computerize our technical information system and storage retrieval so that the land manager, in case he has a problem, can plug into it and get an answer.

My present position was established in 1974 in Washington, D.C. I serve as the focal point for initiating, developing, coordinating, and facilitating programs which will help accelerate the application of forest service research results.

5. A STUDY OF RESEARCH UTILIZATION IN THE U.S. FOREST SERVICE

by

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At CRUSK we do research on the research utilization process; we also try to get the knowledge we produce put to use by studying and improving our skills in the dissemination and utilization (D&U) process. Often, we see in our own utilization work the same principles we observe operating in the D&U networks we study. Today I will be discussing both of these levels, using as an example our four-year action research project with the U.S. Forest Service Research Branch.

We have worked from within the research organization, so it is this part of the Forest Service I will talk about. The comments made by Mr. Hal Marx have covered how the Research Branch is trying to relate to the total Forest Service organization. In our work we have stressed a model which highlights the centrality of the potential user of research in the *total* R&D—D&U process, so we have worked with the Research Branch in a way which puts us somewhat in the role of an advocate for the user. However, since we have been constrained to work from within the Research Branch almost exclusively, the thrust of our analysis and feedback/problem-solving work has been: what can the Research Branch do to improve *both* the production of knowledge and the extent to which it gets used? The analyses I will talk about later are geared to answering this question.

Parenthetically, I might note that researchers always seem to be more interested in such work than are the users. The reward systems of researchers, and others for that matter, are tied up in the *production*, not in the *input*. In fact, most of us here are researchers interested in getting *our* products used. Researchers are more motivated than clients to improve utilization, and agencies such as the Government Accounting Office do audits which heighten this motivation (the Research Branch received an audit critical of its application efforts a few years ago). The backdrop for our work, then, was an agency motivated—at least at the top leadership level—to improve dissemination of findings, and uses to which they are put.

Analytically, we have been working with two important criteria in this process: the researchers' contributions to scientific knowledge, and to applications of knowledge. The former is a necessary but not sufficient condition for the latter.

As Hal Marx' comments might lead you to suspect, the Research Branch has been, historically, more concerned with reaching other researchers as the primary client for research; but the shift is now on toward applied clients, the natural resource managers. We have tried to emphasize the point that a "client analysis" is more fruitful than trying to decide if the knowledge being produced is either "basic" or "applied." We feel that, in many cases, it is almost impossible to look at knowledge and make a basic-applied distinction. Also, even if the knowledge can be classified as "applicable," that is no clue as to whether or not it actually gets transmitted to and put to continued use by clients who are not researchers.

I think this is enough background about our overall approach. The materials in Figure 5–1 will give you more information about the project itself. What I would like to do now is to concentrate on two topics in turn: (1) the action research "R&D Lab Renewal Model" which we have been trying to get put into use in the Forest Service, and (2) the findings about scientific and applied contribution which are emerging from our research within this model. At the end, I will mention some of our learnings about research utilization principles which seem to hold true at both levels: (1) our work with our Forest Service clients, and (2) what our research identifies about how they get their knowledge put to use. From what I have heard at this meeting, I suspect that many of these principles may apply to the Navy situation, as well.

The R&D Laboratory Model

There are four broad areas which we feel competent to work with in an R&D organization, and which we have studied in the Forest Service. These are the

GOALS

To conduct a comprehensive *action-research* project covering the areas of:

(a) Organizational planning and goal-setting
(b) Individual satisfactions, information-processing, and other personal factors
(c) Organizational climate, leadership, functioning
(d) Production and dissemination of outputs for scientific clients *and* for *applied* clients.

Implicit in the notion of action research is a detailed problem-solving perspective for problem-formulation, data collection, analysis, feedback, identification and group problem-solving to work on problem areas, and finally, an evaluation of changes in the organization. The overall sequence will take something like five years (we are four years into the process now).

TASKS

Initial problem-formulation was done through a year's open-ended interviewing, learning, and setting up of an "inside team" from F.S. Washington leadership, primarily in research, but with client representation as well.

Data collection (year two) saw creation of a complete R&D organization questionnaire in the four areas above, and collection of data from a census of researchers and a ⅓ sample of research technicians, with an overall response rate of 94%. A large data reduction and multivariate analysis chore followed, focusing on the criteria of satisfactions, scientific, and applied contribution, with some attention to reward (in terms of G.S. Grade).

Recently we have been involved in guiding the data feedback process with small groups in each of the eight F.S. research stations and the Forest Products Laboratory. The model has been one of teaching problem-solving skills needed to derive problems from data, identify solutions, and build action plans for them. The data have served to: (1) identify predictive models for the criteria (and hence, establish important predictors), and (2) indicate where the stations are on the criteria and their predictors, to establish priorities for problem-identification. Group discussions use these results as a springboard in result-validation and interpretation.

Future work will center more and more in helping the system correct problems identified, and reinforce the strengths. Prime areas for national attention are: (1) a complete look at research applications—appropriate activities, how to measure contributions, and the reward system; (2) development of organizational skills in the stations; (3) testing of a short form of our instrument, geared to use as a management tool: The form will collect ratings of organizational and individual factors, plus look directly at the effects of these factors on satisfactions and contributions.

FURTHER WORK

We have also been working with a medical R&D organization in a more compact version of the project, with an instrument based on the notion of point 3 in the paragraph above. Similar data have also been collected in an educational R&D lab by another researcher. In the future we will finish analyses at individual, project, and location levels, and write extensively.

Figure 5–1 Summary of the CRUSK—U.S. Forest Service Research Study.

focus areas listed as the rows in the model in Figure 5–2. The areas are: (1) the research planning process, both long and short range; (2) organizational factors; (3) individual factors, attitudes, motivations, information processing, and background; and (4) production of knowledge, dissemination, and utilization. We did not prioritize these focus areas, nor put any predictor—criterion models on them before we began to work. This may scare some social scientists; but we began with the "free" approach because we think the criteria and the models need to be set by an organization to meet *its* needs, not ours. What we are saying is that all of these factors are needed to give us a mastery over what is going on in the organization, but that how the areas interrelate and what the important outcome measures are must be specified by the client.

The stages in the action research process, specified working toward the right across the top of the figure, constitute a more active than normal role for the researcher in helping his client understand and use information. Though this process provides, we believe, more useful and used outputs, it has heightened our concern about factors such as long time periods in research projects, the necessity for team building, and the reward systems in science—all factors we will discuss as "parallels" later.

In the first stage of problem formulation, we spent a full year simply getting to "know the territory" and the people in the research organization. This detail paid

A MODEL FOR RESEARCH AND DEVELOPMENT LAB RENEWAL/STRENGTHENING PROCESSES

TOPIC AREA FOCUS	PHASE I: Problem Formulation. CRUSK staff learns about system, and system about what is known in each topic area.	PHASE II: Diagnosis, Description, and Prediction of Where Lab Is/Is Going.	PHASE III: Review Findings and Identify Possible Intervention Strategies.	PHASE IV: Undertaking Multiple Processes for Change, Using Field Experimental Approach Whenever Possible.	PHASE V: Evaluation of Change Efforts, Implementation of the Effective Changes, and Construction of Permanent Problem-Solving Mechanisms and Skills.
On the Future	Long range planning and future forecasting: —How do various staff members and groups look at the future, and what do they see there? —What makes for effective planning processes?	How does the system anticipate future situations, needs, demands, and opportunities? How does the system set objectives and define criteria? Who has what kind of access to the planning process?	Look toward team building to: —clarify mission —identify specific objectives —plan how team efforts will affect the lab —increase participation in the planning process	Build new teams, and reward structure for team work; construct different models for linkage to outside planners, futurists, forecasters; try different approaches to getting more staff input in planning process.	IN ALL FOUR AREAS, IMPLEMENT THE BEST TRIAL INNOVATIONS, GIVING: —better planning and participation in it —better organizational structure, leadership —improve member productivity and satisfaction —increased concern with and activity in dissemination and utilization of outputs, and client linkage/feedback THE BETTER INNOVATIONS ARE THOSE WHICH IMPACT AS MANY ASPECTS OF THE FOUR AREAS AS POSSIBLE.
On the Scientific Lab Environment	Organizational behavior research: —What distinguishes more from less effective lab environments?	What is the scientific working environment as seen by various members of the system? How does structure and process in the system affect individual members?	From the data collected, what do we see which might be changed to improve: —organizational and personal goal attainment —organizational structure itself —identification and use of the "natural" administrators and information linkers in the system?	Structural/organizational changes. Strengthen supervisory/administrative/leadership skills in system by: —reading, discussing —training in use of new skills for leadership —motivating, counselling —building "creative dither" in lab	
On the Scientist or Staff Member Himself	Inputs and outputs: —How do scientists exchange information? —What is productivity, and what predicts it? —What is the reward structure? Individual development: —What are training opportunities? Attitudes: —What do members think of career, job, system, coworkers, etc.?	What are the activities, attitudes, motivations, and needs of system members? What are the information gathering and production mechanisms? How does the reward structure affect individuals? How does all of this interrelate?	What changes might be devised to: —increase satisfaction and productivity —improve the information system —alter reward structure to give "better" products —identify and increase effectiveness of "Technical naturals" within the lab, and to the outside?	Interface structural/organizational changes above with individuals, using increased satisfaction and performance as test of these changes. Try different media for input and output of information, and for intra-system flow/retrieval (both "hardware" and human—e.g., technical naturals).	
On the Outputs Individuals and the Lab Produce, Get Disseminated, and Get Put into Use	Diffusion research: —What are the flow patterns for knowledge—what, to whom, how? Knowledge Utilization: —What is linkage and view of clients, how are they identified, what are their needs, feedback? —What are models for diffusion and utilization of knowledge?	Who are present and potential clients? What are their information needs, and best ways to reach them? How much of what is received is actually used, and for what? How do outsiders perceive the lab, what do they want from it, and how do they make needs known?	What changes might be devised to: —increase lab concern with dissemination and utilization of outputs —improve match of output media with those most used/understood by user —link lab and clients interpersonally so they get better information and lab is affected by their needs?	Try ways to build awareness of need for better dissemination and utilization, increase client linkage, and get client feedback.	THESE CHANGES ARE NOT THE END OF THE ROAD—MECHANISMS, SKILLS, AND REWARDS MUST BE BUILT TO ALLOW THE SYSTEM TO DO ITS **OWN** PROBLEM-SOLVING IN THE FUTURE.
	—THE RESULT: staff knowledge of each field, CRUSK knowledge of the problem areas, and mutual concensus on which areas are important for future work.	—THE RESULT: detailed empirical knowledge of state of affairs in each area, how they interrelate, and causal/predictive conditions; leading to discussion of what can/should be changed, and how.	—THE RESULT: Trial changes developed from understanding of results; a better understanding of the system by both insiders and CRUSK.	—THE RESULT: Evidence of effectiveness of different trial changes. Demonstration to system members that system is "alive" and vitally concerned with constructive change.	—THE RESULT: An organization which has improved its present structure, process, and output; and one which has the capability to change and adjust in the future.

Figure 5—2.—Focus Areas Appropriate for Investigation in terms of technology transfer study.

off in the coverage we were then able to provide in our survey instrument, the predictive power of our analyses, and in the ultimate usefulness of the results. The major "data" from the problem formulation year consist of open-ended group interviews with about 300 persons in the Research Branch and client groups.

From this we went on into the second phase of the model, using a self-administered survey questionnaire covering the four areas. Many of the concepts used were taken from precedent works on research organizations, organizational development, and dissemination and utilization. All of the concepts were, however, filtered through the realities contained in the problem formulation results, and through a Forest Service project monitoring team, in order to insure that we were asking relevant questions. In analysis we have concentrated on criteria dealing with reactions (and satisfactions) with the organization, contributions to knowledge and applications, and increasingly in recent months, the notion of the reward system. We find that interest in these criteria varies within the organization. We have discovered that there is more interest at the top of the organization with issues such as research application, while individual researchers are more concerned with the organizational conditions which help or hurt their work; and contributions of either type. Thus, we have had to keep a wide range of information in the feedback data and reports we have provided for stations, and in the meetings we have held for problem solving based on the results.

What happens during feedback and problem solving? The following phases seem to cover most of the work done separately in the various research stations.

1. *Orientation* of the client to our perspectives, and of us to their current problems; initial meetings with leadership were used, too.
2. *Presentation* of findings dealing with the criteria and with factors which relate strongly to the criteria in nation-wide analyses. Data are always presented in a way which allow them to compare themselves with the rest of the system, and in addition, by important levels (e.g., job status) within their local organization.
3. *Validation* of our findings against the collected experiences of groups from the station. In cases of disagreement between the clients and the data, we explored the reason for the discrepancy, and usually came out agreeing with the clients' judgments.
4. *Problem formulation*, using the data and discussion as *stimuli* for the group to use in brainstorming sessions with the goal of identifying real, continuing problems in that station.
5. *Solution recommendation*, using continuing brainstorming to come up with alternative solutions, evaluate the alternatives, and finish with a list of recommendations for action. The recommendations usually went to station leadership for reactions and implementation.

Our role in the content of this work was greatest during the first two steps, and gave way to increased activity with the *process* used by the meeting participants during the later phases. Validation was a particularly important step, since it was here, in the group setting, that individuals came to feel they understood our concepts and could relate to them. In addition, they had the necessary chance to locate problems in the data or analysis. Several kinds of problems were identified in various locations:

1. Conditions had changed since the data were collected. Here our desire to collect complete data and do comprehensive analyses worked against our desire to be timely. In addition, the Forest Service told us in no uncertain terms that the stations could not hold still, or consent to be control groups for us.

2. We had not asked the right questions. This was particularly true in cases where local conditions differed from those true nationwide. Were we to do the research again, for example, we would probably put more emphasis on the financial aspects of research projects. Where we did have an area covered, however, we found that the items seemed much more on target than in the average survey. This we attribute completely to the amount of work which went on during the first year, and to the fact that items were not added solely from the social scientist's view of how the world (and the concepts working in it) ought to be.
3. Our analyses weren't complete. We found that our clients gave us valuable clues for variables which needed to be considered for qualifying conditions, etc. The fact that they themselves are researchers helped no end here. The comments added both to the predictive power in our revised analyses, and to the utility of the results—primarily since the client could now have more confidence in the findings.

Our general principle running through all of our work is that of direct psychological involvement of the client throughout the process, and of direct interaction between client and researcher at all phases. The "action potential" of the results is much greater if the client feels he understands and somehow "owns" the study, its concepts, and its findings. On the other hand, the client needs help with the process through which the findings get turned into recommendations for supporting good things or changing bad ones. These feelings of ownership are particularly crucial at leadership levels, since these provide a legitimate entry to the staff—and the staff in turn insures that leadership cannot ignore the study and its recommendations.

I think this covers the process of our work sufficiently. The next question involves what we've learned from the research. I have selected three analyses for attention here, taken from the data for all Forest Service Research stations combined.

Some Findings

We will be looking at analyses of the two kinds of contribution researchers can make: that to scientific knowledge itself, and that to applications. We have found that indices of the two kinds of contribution do correlate positively—researchers who are contributing to science also tend to contribute to applications. Beyond this, however, there are different predictive models for scientific and applied contribution.*

The scientific contribution index is the vertical scale in Figure 5-3. Groups have been defined by the computer, as a function of high-low splits on a set of predictors, so as to maximally predict the criterion of contribution by creating groups (in a non-symmetric manner—the technique is called Automatic Interaction Detection). Notice one thing about the strategy we are using—we have not brought back to the client any regression or correlation analyses. We have found that it is difficult even for researchers to derive action implications from correlational findings. They seem to need *levels* on defined variables for *groups* of identified type and size.

The analysis shows us that the highest contributors to science in the Forest Service Research Branch are research team Project Leaders who are also "self starting," in that they get a greater than average amount of stimulation to perform

*Both measures equally weigh appropriate questionnaire responses in three areas: number of written outputs in last five years, number of events attended, and opinions about contribution.

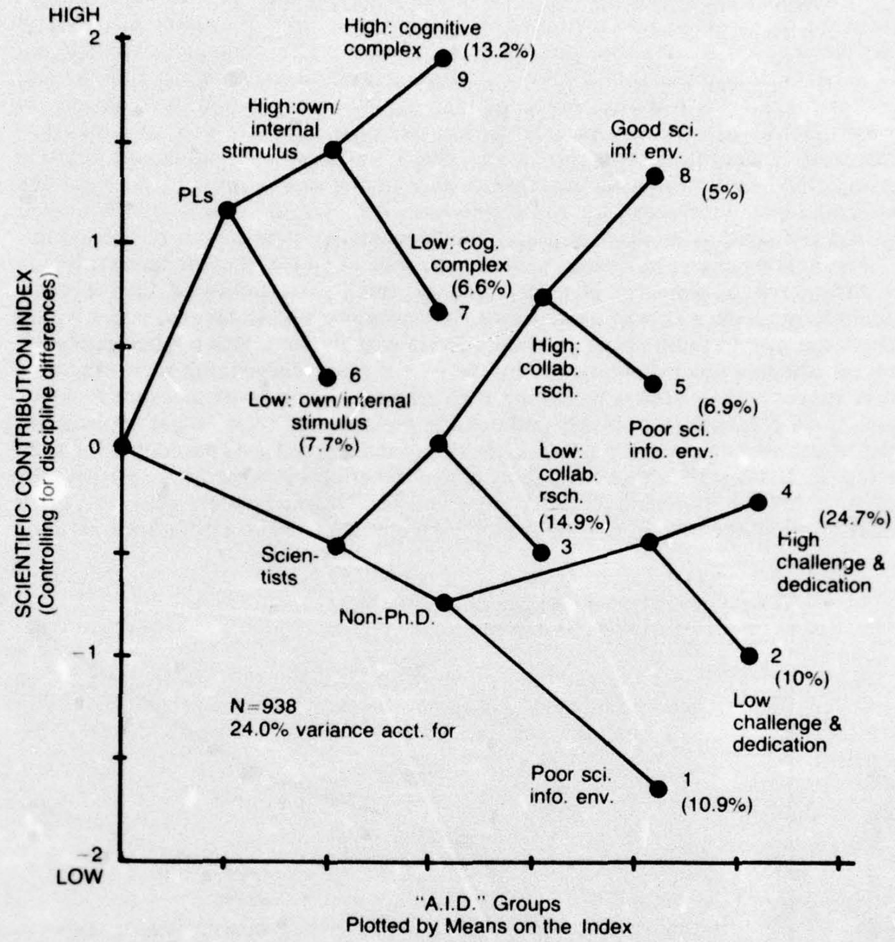


Figure 5–3 "A.I.D." Analysis of the Scientific Contribution Index (Data from scientists and PI's)

well from their own work, ideas, and curiosity. They are also more "cognitively complex," that is, they prefer to handle many aspects of a problem at once, rather than working on one facet at a time in a linear fashion. The combination of these three factors, then, defines the highest group, making up about 13 per cent of the researchers in the organization. Scientists, as opposed to Project Leaders, can "compensate" for their lower role in the organizational structure by having a Ph.D., being more active in inter-project and inter-displinary collaborative research, *and* having a good scientific information exchange environment. The scientific information environment and feelings of high challenge in work and dedication to work help the non-doctorate Scientists. On the bottom in terms of scientific contribution are Scientists without a doctorate who say their scientific information environment is bad. Organizational factors, then, seem critical for the scientific contribution of scientists but only personal cognitive and motivation factors are important to the contribution of the research leaders. (Most of whom were probably selected for their job because they had these characteristics.)

In feedback we would compare the percentages in each of these nine groups from the nation-wide data with percentages in the station. We would also look at the mean scores of the nine groups in the station, again compared with the national data. If a station found it had more researchers than average in a low group, and/or a lower contribution score for that group, then it would have an idea of which factors to work on for change. For example, if 20 per cent of a station's research Scientists showed up in the non-Ph.D.—poor scientific information group, then that station would have a clue that it *might* need to improve the information environment for these persons. We "might" because this finding would still need to be discussed and validated by the experiences of the group.

The next example, in Figure 4, covers the index of applied contribution. It is in a different form for ease of understanding, but it was produced by the same analytic procedure as was used above. What we are saying here is, and I would challenge you to think about your own R&D organization, that applied contribution is affected most dramatically by the extent researchers think their organization supports their efforts in linking with clients. The support measure includes perceived pressure from inside and outside the research team to get application; the extent the supervisor pushes application; and the rewards perceived for such work, also. What the three plots show is that the effects of support are positive for all three groups, though a bit more important for Project Leaders who get a great deal of stimulus from client problems. Client stimulus makes a difference, as does

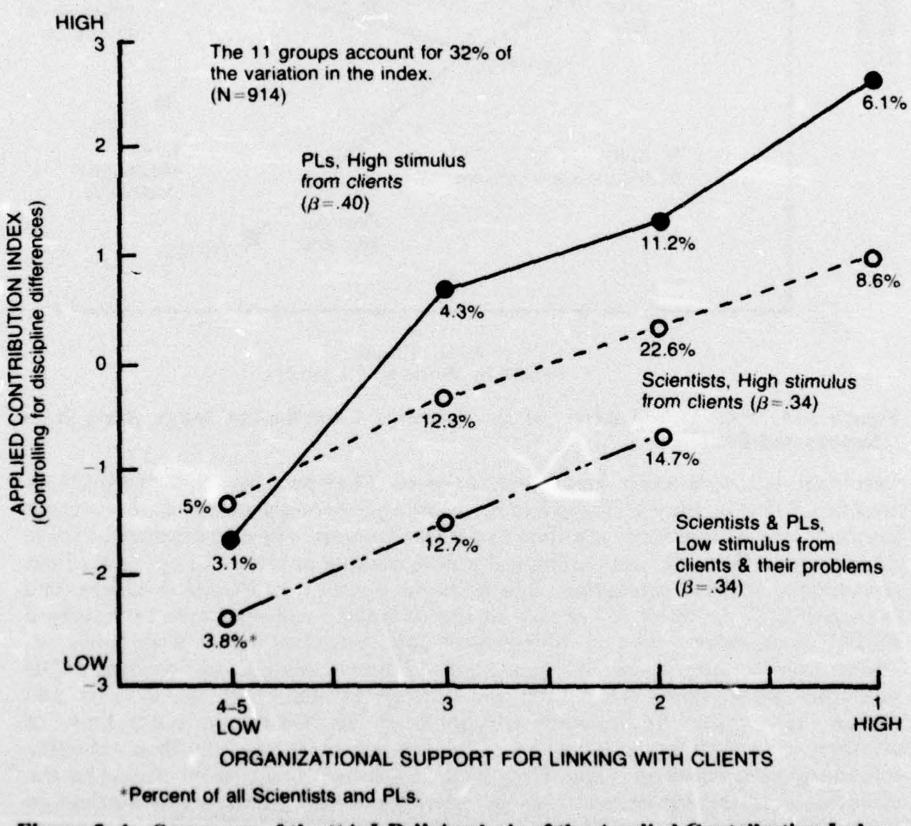
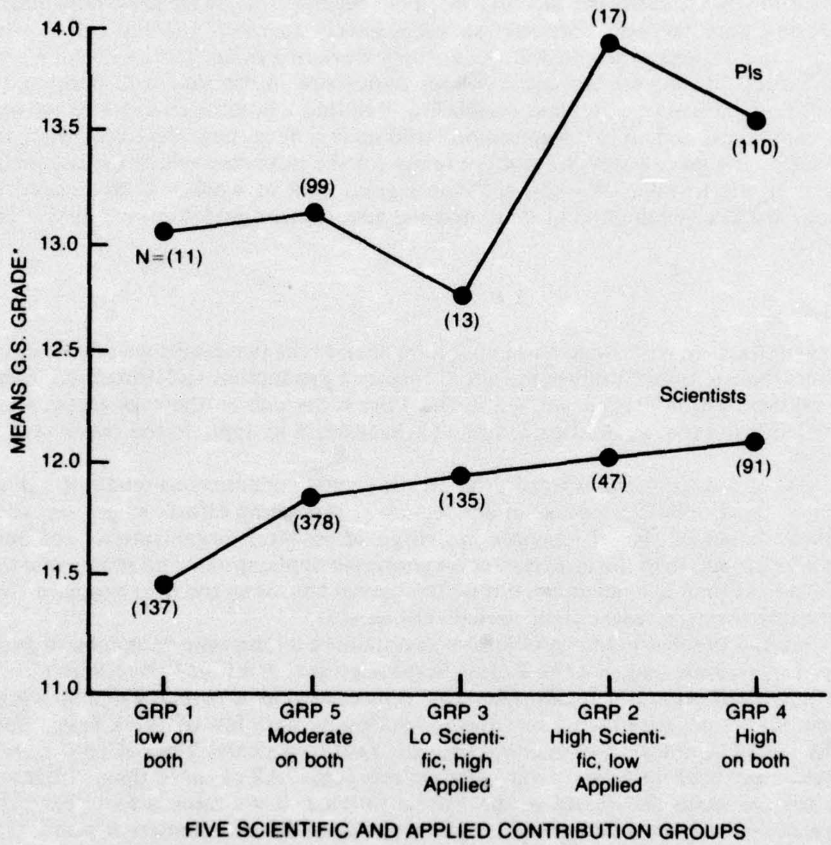


Figure 5–4 Summary of the "A.I.D." Analysis of the Applied Contribution Index. (Data from Scientists and PLs)

job status *if* the researcher is high in getting this stimulus from clients. So, job status, stimulation from clients, and a overall organizational support, are the important factors to know about in predicting applied contributions. The support dimension, in particular, has come in for a lot of discussion during feedback as a controlling factor in the amount researchers get active in applications. This brings us to the final analysis.

Just how do the two contribution factors relate to rewards researchers receive? To answer this we divided researchers into five groups, as a function of their scores on the two contribution measures, and then compared the average G.S. Grades of the groups, after controlling for background and experience factors. The results are in Figure 5.



*Means adjusted to remove effects of background factors listed below.

Table of Covariates.		Scientists		PLs	
		t	p<	*t*	p<
Level of education		15.1	.0001	3.5	.001
Years since education completed		8.0	.0001	4.2	.0001
Years in Forest Service research		6.5	.0001	2.3	.05
Equality of adjusted means:	d.f.	4,680		4,242	
	F	6.8		7.1	
	p<	.0001		.0001	

Figure 5–5 Analysis of Covariance for G. S. Grade of Five Scientific and Applied Contribution Groups.

What we see is that, for research team Project Leaders, those who are high in applied contribution are about one half a G.S. Grade lower than their colleagues, regardless of where they are on scientific contribution. Compare groups one and three: the only difference between them is that group three is high on applications, while both are low in scientific contribution. Here group three is half a grade lower, even though, objectively, they are at least contributing in one area. More serious is the cut taken by group four as compared with group two. Project Leaders in group four are high in *both* kinds of contribution, but they are still half a grade lower than their peers who are high only in scientific contribution. The reward system for Project Leaders, then, appears to give a negative reward for applications. For Scientists, the picture is not so bad—we see a general positive trend for G.S. Grade as the Scientist becomes high in either area and finally both.

During data feedback, discussion immediately turns to the big issue: why *doesn't* the organization reward applications work of Project Leaders? As we've said earlier, the Forest Service has been concerned in the past with building its scientific legitimacy, academic credibility, building laboratories close to university campuses, and so on. Reputation building is a necessary step; but, what we are seeing is that rewards are not yet ready for the next step which the organization is trying to take. We suspect that a great deal of work will be needed to change the peer evaluation system, and the government guidelines for evaluating science.

Parallels

I want to close with some parallels I have seen at the two levels we talked about earlier: the use of our knowledge about research production and utilization in the Forest Service, and what we see in the Forest Service as they try to get their knowledge put to use. As I said, some of these seem to apply to the Navy setting as well.

First, of course is the reward problem. It seems endemic—as much of a difficulty in the Forest Service as in academics in rewarding efforts to get research applied. It seems that the people in charge of research organizations are only beginning to move in the direction of emphasizing application—and more so in the government than in academics; but neither group has taken the next required step of putting rewards where their verbalizations are.

A second parallel is that problem of maintaining a long-time sequence of projects. I have indicated that the Forest Service project is a four to five year effort. We have had difficulty maintaining our momentum as a research team. Social Scientists are geared to work on short range things. Very few of us are psychologically keyed to not having an answer for the next four years. This, of course, ties immediately back into the reward system problems. All of these things interact. We see the same difficulties in the Forest Service: if we think a five year time sequence is bad—what do you do if you want to study the complete regeneration of the forest? It may take a generation before the project is done, creating a motivation and momentum problem. So both of us (we and the Forest Service) seem to have problems in terms of time scale; I haven't heard this mentioned as so great a problem in Navy R&D, however.

Third, is another time problem parallel, that of turn-around time. Our analysis, being as detailed as it was, took something like a year or a year and one-half. As I said, the organization moved out from under us. In the Forest Service, we hear the same thing. We hear clients complaining that, "By the time you guys came back with your solution to the problem, we had simply flipped a coin for a solution and went on. That was last year's problem. This year's problem is x, y or z. What do you have to tell me on that?" It seems that researchers are still tied to the .01

level or even the .001 level of significance before they will say anything, even though the real world often makes decisions on the flip of a coin. Clients are saying to us all the time, "Why don't you give me a 60-40 guess?" If you stop and think about it many of us researchers change hats. We take off the conical peak hat of the academician and put on the hard hat of the consultant. We will go out into the real world and we will help people. What we do when we do that, is forget the data and fire from the hip. We use our hunches, which are educated guesses, based on what we think is going on. We are not staking our reputation on a probability level. Clients are asking us to do more of this, even within our research projects. With both systems we have some problems doing this. This is probably true for the type of research that you do also.

Fourth is familiarity with the client. This is a crucial factor in the success of research, primarily, I maintain, because of the fact that research must be designed to meet the needs of the clients. It is also required to help solve problems. I have a rule of thumb. About the time that I feel you could go to work as a researcher for that organization, or about the time you go to a meeting and are mistaken for an employee of the organization, then that point in time you are at the level where you can begin to make some positive inputs to that organization. Before that it is best to be quiet.

Fifth is the problem of the R&D to client ratio. This ratio brings in the need for linkers and person multipliers. These concepts have also been discussed during this meeting. Our project used two people. On the average there has been one scientist man year on the project. There are about 1,000 researchers in the Forest Service R&D community; but at least 40,000 to 50,000 who could be potential users of the information they produce. That ratio is very large. Something needs to be put into the middle. We all have learned that people make better people multipliers than impersonal media—both we and the Forest Service are beginning to move into the area of training other people to translate knowledge and pass it along. The Department of Agriculture started the extension concept; but somehow there has been a problem in carrying the concept over into the Forest Service.

The sixth parallel is that we all have to learn that researchers cannot take all of the blame for lack of use of knowledge. Again it goes back to what people are rewarded for. We have had a few reward problems in that we are demanding a fair amount of time from people out in the field. Time was needed to derive solutions based on what we had found, but they may not get rewarded for giving us this time. The Forest Service researchers have the same problem. It doesn't say in a Forester's job description; "one of the things you will do, and get rewarded for, is listening to the researchers." I don't know of anybody's job description in any agency which is written this way.

Seventh is the parallel of organizational support, the thing that we saw was so important in applied contribution. Social science is still overly concerned with the academic image and rewards researchers for contributions made in narrow scientific specialties, as judged by scientists themselves. R&D organizations seem to be unable to break the mold, provide support for their staff, and put pressure on the larger academic community that what the lab and its people do is valuable and important.

The eighth parallel is one which I see in all of the systems: that is the "musical chairs problem." Just about the time we in our research get someone trained in one of the stations to know what we are talking about, or just about the time that the Forest Service research branch gets one of the people out in the regional office trained, or just about the time you get that Navy Captain so that he knows what you are talking about, the person is gone. The turn-around time seems to be something like two years. Then you must start all over again. We are not too bad

off because our client ratio is still 2:1000 or so, and there are probably only 150 top administrators in the system. Usually when people leave from a station at which we have worked, they either go out to retirement or they go up. Many have moved up or across to other stations. People that we worked with earlier are showing up in surprisingly useful places. I suspect that this does not happen with the clients in Forest Service research because when clients "go up" they tend to get moved to another region, away from the station's territory. In the case of the Navy, I would suspect the problem is even more severe. We all need to think of mechanisms which will make our application inputs "transfer-proof."

The ninth and final point involves the need to work in teams. We need to because we are concerned with doing good social science and with the group processes required to get our results and model put to use. We also need team members who "know the territory" of natural resources. The Forest Service is also moving more to interdisciplinary teams as they come to work on more "real-life" problems. Most researchers are too narrowly trained to be able to do justice to the scope demanded in most "real" problems.

In conclusion, I have tried to illustrate the process we have used, together with some of our findings from the Forest Service project. Both what we have learned in the process and about the Forest Service point to a series of parallels. The parallels stress the importance of providing organizational conditions and supports (particularly rewards) which permit researchers to contribute to both science and application at the same time. The dual contribution makes tremendous demands on researcher and organization alike, and means we have much to learn about being timely, involved, broadbased, and relevant to our clients.

References

The Forest Service Project is described in two documents, Annual Report FY 73-74 and Annual Report FY 74-75 by David A. Lingwood and William C. Morris. These reports are available from Center for Research on Utilization of Scientific Knowledge, Institute for Social Research, University of Michigan, Ann Arbor, Michigan.

6. A STUDY OF THE PRESIDENTIAL INTERNSHIPS IN SCIENCE AND ENGINEERING

by

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The Presidential Internships in Science and Engineering Program was initiated in 1971 under the administrative control of the National Science Foundation, with funding being provided by the Department of Labor.

This program enabled unemployed or underemployed scientists and engineers holding advanced degrees to work for a year at Federal Research and Development laboratories. A one year nonrenewable stipend of up to $7,000 per year was granted to each intern with the laboratory providing matching funds or, in many cases, larger amounts.

The internships were intended to help the scientists and engineers to broaden their work experience, thereby facilitating their transition to future jobs needed by society. To this end, a total of 557 scientists and engineers were granted internships at 72 laboratories before the program was concluded in the spring of 1973.

It is unfortunate that no system for monitoring and evaluating the program was established before it was started. At the time the program concluded, little was known about its success or failure in accomplishing its objectives.

In late 1973, and early 1974, two naval officers who were enrolled in a program leading to a Masters Degree in Management at the U.S. Naval Postgraudate School, undertook a study of the internship program.[1] This report describes and summarizes their thesis and their effort in preparing it.

The Purpose of the Study

The study was initiated in an effort to measure the effectiveness of the Presidential Internships in Science and Engineering Program. The specific objectives of the study were as follows:

1. To determine if the program helped the interns to obtain employment in the science or engineering fields.
2. To determine if the interns provided the laboratories with a specialized talent.
3. To determine how long it took the interns to become productive members of their laboratories.
4. To determine what effect the internship had on influencing the interns to seek a doctorate.
5. To determine if the interns' salaries and advancement patterns were equivalent to those of their contemporaries.
6. To determine if the internship increased the interns' capability for technology transfer.
7. To determine how technical information was transferred between the interns and other members of the laboratory, and to examine how information was obtained by laboratory members.
8. To determine if there were identifiable barriers to the transfer of technology between the interns and other members of the laboratory.
9. To determine some of the characteristics of the interns involved. Of particular interest are those characteristics that can be associated with the linker and stabilizer concepts described by Creighton, Jolly, and Denning. (Ref. 2).
10. To determine if specific intern characteristics were related to their performance at the laboratory.

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[1]Cater, Charles E. and Korsmo, Thomas B., Masters Thesis, A Study of the Presidential Internship in Science and Engineering, June 1974. Copies are available from the Defense Documentation Center, Cameron Station, Alexandria, Virginia 22314.

The Background for the Study

During the period in which the Presidential Internships in Science and Engineering Program was initiated, highly qualified young scientists and engineers were enduring a particularly high unemployment rate in the airframe industry. Dr. Edward E. David, Jr., Science Advisor to the President, commented that "these unemployed people could provide a unique source of skills and resources, much of which was developed at taxpayers' expense in colleges, universities, and various laboratories." In a sense, these people represented a vital national resource that was not being effectively utilized.

Concurrently, there was a growing need throughout the country for research in such areas as pollution control, trash disposal, management and integration of large projects, and the nuclear field in areas as diverse as new power systems or criminal and medical laboratories. The internship program could provide temporary employment for scientists and engineers, expose the trainees to both the problems and the capabilities of government research and development institutions, and send technological specialists into the mainstream of government units which had previously not been able to afford such expertise.

It made a great deal of sense for the federal government to protect its interests by devising means to utilize the skills that it had helped to develop. One of the main thrusts of this study was to evaluate the accomplishments of the internship program as a means of utilizing these skills.

An essential key to the success of this program would be the ability of the laboratories and interns involved to transfer technical information and knowledge from one to the other. Technology transfer has been defined by Gruber and Marquis as "the acceptance by a user of a practice common elsewhere, or it may be a different application of a given technique designed originally for another use." (Ref. 3, p. 255–6). An example is the widespread adaptation of many of the space program developments, such as teflon and sub-miniaturization of electronic components, to commercial applications.

If one accepts the principle that a considerable amount of the nation's research and development effort involved devising different uses of existing ideas, or further sophistication of known concepts, then it follows that an important facet of research and development is the capability to discover and transfer what has already been learned from one user to another.

Another important factor to be considered regarding the internship program is the capability of the program participants to develop and utilize innovative concepts. Barnett calls innovation "a new thought, behavior, or thing which is different from existing forms." (Ref. 1, page 7). It is certainly not difficult to conclude that the solution to such relatively recent areas of public concern such as pollution control and trash disposal, which had not been generally recognized as high priority national problems in previous generations, would require some innovative techniques.

Creighton, Jolly, and Denning (Ref. 2) have suggested that certain characteristics of some individuals would render them more effective in accomplishing the technology transfer mission than others. They went on to describe those individuals who exhibit the traits of a gatekeeper (one who holds the strategic position in terms of the flow of knowledge from source to application (Ref. 4, pp. 7–11), innovator (early adapter of an innovation), early knower (one who consistently takes initiative on his own behalf to seek out scientific knowledge and derive useful learnings therefrom (Ref. 4, pp. 7–41), and opinion leader (the individual from whom others seek information and advice).

Individuals who display a high degree of conformance to this description have been termed by Creighton, Jolly, and Denning as linkers while those who show

fairly little conformance were called stabilizers. They further hypothesized that there would be a relationship between the output efficiency utilization of research and the behavioral characteristics of the individuals in the user activities.

If linkers and stabilizers could be identified in the intern group, it would be of interest to analyze their performance characteristics, as viewed by their supervisors, in order to see if there were any significiant differences and if one group or the other achieved superior performance results. Identification of such relationships, if they existed, could be of value to the laboratories and others who are concerned with acquiring services of people to accomplish research and development tasks.

It would be presumptuous however, to assume that the interns themselves had complete control of their destinies, and it should be recognized that the nature of the laboratory itself would have some impact on the ability of the interns to function as either linkers or stabilizers. If, for example, a laboratory had established policies that would serve as barriers to the adoption of technological innovation, it would perhaps be difficult for a linker oriented individual to realize his full potential. Barriers, in this context, could include such things as failure of the laboratories to encourage and reward innovative suggestions, failure of supervisors to recognize and accept their subordinates' ability to develop useful new concepts, failure of the organization to maintain adequate channels of communication whereby employees can readily bring innovative suggestions to their supervisors' attention, and many others. It is also likely that some factors that may appear as barriers or demotivators to some individuals may not have the same detrimental effect on others.

With these thoughts in mind, the study was launched in quest of information that would prove relevant to the concepts discussed above.

Description of the Study

A survey of the scientists and engineers who participated in the internship program was conducted. It was anticipated that some of the interns and supervisors would no longer be employed at the internship laboratories. Therefore, it was almost certain from the outset that it would be impossible to survey all interns or supervisors or even to obtain a truly random sampling of the original population.

With these limitations in mind the sample population was selected from the laboratories that participated in the internship program. The sample was not random in that it was limited to those laboratories in the California area, or laboratories with a large number of interns, and/or Department of Defense laboratories that could be contacted by Autovon telephone. These limitations were imposed as a method of minimizing the cost of the study and facilitating a quick response. The lack of random sample violates a prime requirement for statistical significance implications to the total population. Therefore, the study team was able to apply the statistical measures only to the population of the sample.

A self-designating questionnaire was developed based upon a research of the literature which examined the characteristics and qualities of the linker. The self-designation method was adopted as an effective but economic method of identifying the effectiveness of the program in that the individual's perceptions are what actually affect his behavior. (Ref. 5, p. 216).

Fifteen of the 72 laboratories involved in the internship program were selected. These laboratories employed 137 of the 557 interns. Questionnaires were sent to them. The mailings and responses are shown in Table 6–1.

TABLE 6–1
QUESTIONNAIRE DISTRIBUTION

Location	Sets Mailed	Number Returned Intern	Number Returned Supervisor
Cold Regions Research and Development Laboratory	4	4	3
Brookhaven National Laboratory	15	9	9
Frankford Arsenal	3	2	1
Lawrence Berkeley Laboratory	9	4	0
National Aerospace Medical Research Laboratory	2	1	2
National Center for Earthquake Research	3	3	1
Naval Electronics Laboratory Center	8	5	6
Naval Missile Center Point Mugu	4	1	2
Naval Ordnance Laboratory	2	1	2
Naval Research Laboratory	44	30	0
Naval Ship Research and Development Center	6	4	4
Oak Ridge National Laboratory	12	8	0
Pacific Southwest Forest and Range Experiment Station	2	1	2
Picatinny Arsenal	10	6	9
Western Regional Research Laboratory	12	8	9
TOTALS	136	87	50

A number of the interns and their supervisors were personally interviewed by a research team member. The interviews clarified unexpected responses and identified results of the program not examined by the questionnaire.

Questionnaires

Two separate questionnaires were distributed, one to the interns and the other to the supervisor in the laboratory under whose guidance the intern worked.

The intern questionnaire was composed of 29 semantic differential questions, directed toward identifying the effectiveness of the program, and three open-ended questions dealing with biographical data.

A second questionnaire in two parts was intended to determine the professional atmosphere of the laboratories as it affected the attitudes and performance of the interns and to determine the supervisor's evaluations of the interns' characteristics and productivity. Each question was associated with one or more questions in the intern questionnaire.

Results Matched to Specific Objectives

This section matches responses to the questionnaire with each of the objectives of the study. The objective is stated, a summary of the findings pertaining to the objective is given. This is followed by a summary of the responses to each question which contributed to that objective.

Objective 1. To determine if the program helped the interns to obtain employment in the science or engineering fields.

Seventy-eight percent of the interns strongly agreed or agreed that the internship helped them obtain employment in their fields and 76% strongly agreed or agreed that the internship increased their employment opportunity. Ninety-four percent of the supervisors strongly agreed or agreed that they would recommend the interns for employment. Only one supervisor disagreed.

The number of interns employed increased from 40 before the internship to 78 after. Three of the interns went back to school after the internship while six of them were unemployed. The total number of interns not holding jobs in their field decreased from 62 before the internship to nine after. Of those six interns who were unemployed after the internship; one had been previously under-employed, two had been employed in their field, and three had been in school.

Objective 2. To determine if the interns provided the laboratories with a specialized talent.

Forty-eight percent of the interns and 46% of the supervisors strongly agreed or agreed that the interns provided the laboratory with a specialized talent. Forty-four percent of the interns and 48% of the supervisors felt that the interns professional knowledge was either far greater or greater than the interns' contemporaries. Only 7% of the interns and 10% of the supervisors felt it was less.

There was a moderate disagreement between the interns' and supervisors' responses regarding the interns' major value to the laboratory. The interns felt more strongly that their major value was the knowledge they brought with them to the laboratory or their ability to develop new concepts, with 59% of the interns selecting one of these responses. On the other hand, 58% of the supervisors indicated that the interns' ability to understand and use concepts already in use at the laboratory or to carry out instructions given by others was the interns' major value to the laboratory.

Objective 3. To determine how long it took the interns to become productive members of their laboratories.

Sixty-three percent of the interns and 50% of the supervisors felt that the interns had become productive within two months. Only 2% of the interns and supervisors felt that it took the interns longer than six months to become productive.

Thirty-nine percent of the interns and 68% of the supervisors thought that the interns had become productive faster than most other new members.

Objective 4. To determine what effect the internship had on influencing the interns to seek a doctorate.

Fifty-six percent of the supervisors strongly agreed or agreed that their laboratory's policy was to encourage interns to seek advanced degrees, while 10% of the supervisors disagreed with this statement.

Of the 45 interns who did not have a doctorate prior to the internship, 31 indicated that the internship had no influence upon their desire to seek a doctorate and that they had already decided one way or the other. Eight interns said the program encouraged them to seek a doctorate and four said the internship discouraged them.

Objective 5. To determine if the interns' salaries and advancement patterns were equivalent to those of their contemporaries.

The interns' and supervisors' responses regarding the interns' advancement pattern were quite similar. Twenty-nine percent of the interns and 34% of the supervisors agreed or strongly agreed that the interns' advancement pattern was better than their contemporaries, while 25% of the interns and 26% of the supervisors disagreed or strongly disagreed with this supposition. The most frequent answer chosen by both groups was "undecided."

Sixty-three percent of the interns felt that their salaries were either higher or much higher than their contemporaries, while only 6% felt they were lower.

Objective 6. To determine if the internship increased the interns' capability for technology transfer.

Seventy-eight percent of the interns and 80% of the supervisors agreed or strongly agreed that the internship had improved the interns' technology transfer capability, while 10% of the interns and only 2% of the supervisors disagreed or strongly disagreed with this statement.

Objective 7. To determine how technical information was transferred between the interns and other members of the laboratory and to examine how information was obtained by laboratory members.

Fifty-one percent of the interns felt that the way in which the laboratory shared scientific information was either outstanding or completely satisfactory, while only one intern indicated that he felt the laboratory was completely unsatisfactory in this regard. Sixty-seven percent of the interns agreed or strongly agreed that they were satisfied with the amount of information they received about what was happening at the laboratory and 60% of the supervisors either agreed or strongly agreed that the top management of the laboratory was effective in keeping the scientists and engineers informed about what was going on. One supervisor strongly disagreed that his laboratory was effective in sharing information. The negative responses to questions regarding the distribution of information in the laboratories were generally spread among several laboratories with only one receiving predominantly negative responses.

Ninety-two percent of the interns indicated that they were able to relate in technical areas with two or more other members of their laboratories, while only one intern could relate with no one. Twenty-five percent of the interns thought they could relate with more than six other laboratory members and several of them indicated that they could relate with anyone in the laboratory.

By far the response most frequently chosen as the most effective way of exchanging technical information in the laboratory was "informal discussions on a one-to-one basis" with 83% of the interns and 56% of the supervisors in agreement. Only 3% of both the intern and supervisor groups indicated that written memos or reports, or formal meetings were most effective.

Fifty-nine percent of the interns indicated that other scientists and engineers from their laboratories were their major source of scientific or technical information and 48% of the supervisors felt that discussions among this group was the major method of obtaining information. Twenty-four percent of the supervisors thought that discussions between laboratory members and scientists, engineers and educators from other activities was the major way of obtaining scientific information, but only 6% of the interns felt that this was their major source of information.

Most of the supervisors (64%) felt that if the intern assigned to him had an idea he thought would be useful to the laboratory, he would be most likely to discuss it with his supervisor and only two supervisors said the intern would write a report or implement the idea on his own authority.

Objective 8. To determine if there were identifiable barriers to the transfer of technology between the interns and other members of the laboratory.

The majority of the interns (73%) and supervisors (60%) either disagreed or strongly disagreed that the paperwork requirements of their laboratories were often unproductive.

Seventy-two percent of the interns and 88% of the supervisors either agreed or strongly agreed that the laboratory management encouraged its members to incorporate innovative ideas. Of 12 interns who disagreed that the laboratory encouraged innovation, nine were assigned to stable departments that had few

changes in scientific personnel. Remarks made by interns during the personal interviews showed some belief that older, well-established departments are not as likely to encourage innovation as newer ones.

Fifty-five percent of the interns and 88% of the supervisors strongly agreed or agreed that the laboratory gave individual recognition or financial rewards to members suggesting new ideas. A much larger percentage of interns than supervisors (25% vs. 6%) disagreed or strongly disagreed with this statement.

Most of the supervisors (70%) either agreed or strongly agreed that most of the innovative ideas or techniques suggested by the interns were accepted by the laboratory. Oddly, the interns who worked for two supervisors who strongly disagreed that the laboratory accepted innovative ideas both said that all of their suggestions were accepted.

There was no general consensus among either the interns or the supervisor as to the primary reason that the laboratory did not adopt all of their innovative suggestions. The answer most frequently given what that they did not meet the laboratory's needs, with 24% of the interns and 30% of the supervisors choosing this answer.

Sixty-one percent of the interns and 72% of the supervisors felt that the restrictions imposed on scientists and engineers in incorporating new ideas were minimal or very reasonable. Only one supervisor felt the restrictions in his laboratory were excessive.

Most of the interns (86%) agreed or strongly agreed that their supervisors had an open door policy. There was only a moderate indication that those six interns who disagreed or strongly disagreed with this statement felt that their laboratories were restrictive in incorporating new ideas, did not encourage innovation, or did not give individual recognition.

> *Objective 9.* To determine some of the characteristics of the interns involved. Of particular interest are those characteristics associated with the linker and stabilizer concepts described by Creighton, Jolly, and Denning. (Ref. 2).

Fifty-two percent of the interns and 62% of the supervisors indicated that the interns had supplied one or two original ideas for projects. Six percent of the interns and one percent of the supervisors said the interns had provided five or more original ideas.

Thirty-seven percent of the interns said they had recommended three or four articles to their colleagues, 15% had not recommended any, and only one had recommended six or more.

Fifty-eight percent of the interns indicated that they regularly read up to six journals, magazines, or newspapers. Forty-two percent read seven or more. None of the interns indicated that they did not regularly read at least one periodical.

Three times as many supervisors disagreed or strongly disagreed that they went to the intern as a frequent source of information as those who agreed or strongly agreed. The largest single grouping however was the 44% who were undecided.

Seventy percent of the supervisors agreed or strongly agreed that most of the ideas suggested by the interns were accepted by the laboratory while only 12% disagreed or strongly disagreed.

> *Objective 10.* To determine if specific intern characteristics were related to their performance at the laboratory.

It was speculated that those interns having the strongest linker traits would have different performance characteristics than those with stronger stabilizer traits. In an effort to prove or disprove this supposition, intern questions which were designed to measure linker-stabilizer traits were cross-tabulated with the related supervisor questions which should give an indication of the interns' performance. For this analysis, only those questionnaires that provided match-ups

between interns and their individual supervisors were used. This resulted in a substantial reduction of the sample size of 31 intern-supervisor match-ups. The results of this cross-tabulation showed no apparent relationship between performance characteristics and linker-stabilizer traits.

Next, an analysis was performed by combining the scores on selected intern questions and ranking the interns according to total scores obtained. The upper group was designated as potential linkers, the lower group as potential stabilizers, and the indiscriminate middle group as neither potential linkers nor stabilizers. The linker-stabilizer groups were then cross-tabulated against the same supervisor questions listed in the preceding paragraph. Again, no apparent relationship existed between the performance of characteristics and linker-stabilizer traits.

Various other combinations of cross-tabulations between intern questions designed to measure linker-stabilizer traits and supervisor questions that indicated intern performance all failed to produce any significant relationships between the two.

Analysis

The responses from the interns' and supervisors' questionnaires were recorded on computer cards and analyzed by utilizing a set of computer programs called the Statistical Package for the Social Sciences (SPSS). These programs provided the means to obtain a timely overview of the data received.

The SPSS program was used to provide cross-tabulations, to compute values of chi-square and to compute Pearson Produce-Moment Correlation Coefficients. These three methods of comparing responses to various combinations of intern-supervisor questions were used to identify relationships among the question responses.

The cross-tabulations simply provided contingency tables which, although not particularly useful by themselves, were the basis for the determination of chi-square significance levels. The chi-square significance levels were in turn used to measure the degree of inter-dependence between the two questions being compared.

Very few of the comparisons produced a significance figure of 5% or less, which was the risk level considered appropriate for this study. This result indicated that the response patterns for the two groups, interns and supervisors, were not inter-dependent in general. That is, the two groups tended to respond differently even when asked identical questions.

The major areas in which their answers appeared to be inter-dependent were in regard to the extent of laboratory restrictions, the effect of the internships upon the interns' technical transfer capability, and the propensity of the laboratory to encourage innovation.

The number of chi-square comparisons made was limited to those matchups that appeared to be particularly pertinent to the study.

Pearson's correlations were computed for all possible combinations of intern-supervisor questions in order to ascertain if there were any linear relationships between the answers given by the interns and their supervisors. Those combinations that resulted in a correlation significance factor of 0.05 or less were examined in greater detail in an effort to determine which specific factors were related. Some of the more significant relationships were summarized as follows:

1. The interns were more likely to feel that the program helped them to obtain employment when their laboratories had relatively few restrictions.
2. If the interns thought the program increased their employment opportunity, the laboratory was likely to have encouraged and rewarded innovation, and to have exercised few restrictions.

3. Where the interns felt that the laboratory encouraged innovation, laboratory restrictions were apt to be minimal and most of the interns' ideas were accepted by their supervisors.
4. Interns who thought the laboratory rewarded innovation were judged by their supervisors to become productive faster than others.
5. The interns who were assigned to the more stable departments felt they had a better advancement pattern than their contemporaries.
6. The interns who thought their supervisors had an open door policy took less time to become productive, had most of their ideas accepted by the laboratory, provided the laboratory with a specialized talent, had a better advancement pattern than their contemporaries, and were considered by their supervisors to have a greater degree of professional knowledge than their contemporaries.

Conclusions

From the outset, it was apparent that the large majority of interns were helped by the internship program. Over half of the interns remained with the laboratory upon completion of the internship and most of the others were either adequately employed in their field of expertise or had returned to school. The internship program also gave the laboratories a unique opportunity to evaluate the performance of the interns inexpensively and with a minimum of contractual obligation. Personal interviews with supervisors and personnel managers resulted in a clear-cut consensus that they felt the program had been really beneficial to them. In most cases, the supervisors would have gladly retained the interns assigned to them under this program if funding and personnel ceilings had permitted.

Although the interns appeared to have provided the laboratories with technical expertise they could not have otherwise afforded, there seemed to be a tendency for the supervisors to view the interns' role more as trainees or helpers than as research specialists. Personal interviews with some of the supervisors revealed a lack of complete knowledge of the objectives and ground rules of the program. In one case, for instance, the supervisor was not notified in advance that an intern was going to be assigned to him and was not advised of the purpose of the assignment. While it is not known how widespread this lack of program knowledge was, there is some evidence that better communication throughout the laboratories at the beginning of the program could have resulted in better utilization of the interns' skills.

The ability to communicate and utilize concepts that are considered technological advances has been discussed as a primary characteristic required of the program participants. If this is so, then the technology transfer capabilities possessed by the interns should have been a considerable asset to the laboratories. A large majority of the interns supplied at least one original idea for non-routine work-related projects that were completed by the laboratory, with many of them providing several such ideas. Additionally, it was apparent that both the interns and their supervisors thought that the intern's technology transfer capability was improved during the internship period and this increased ability should prove even more useful to them in future assignments.

An element that should be of considerable importance to laboratory managers is the means by which technological information is exchanged among their scientific work forces. In this case, one-to-one discussions between laboratory personnel were by far considered the most effective means of exchanging such information. Small informal group discussions nearly completed the number of methods that laboratory personnel felt were effective devices for communicating technical information. Written reports and formal meetings were not considered by many to

be the best means of accomplishing this task. These conclusions result in the requirement for laboratory managers to consider ways that technological information can be effectively distributed to more than one other person or to large numbers of personnel. Perhaps one answer lies in the identification and more deliberate planned use of his linker-oriented personnel.

Although there are no set criteria for classifying individuals as linkers or stabilizers, it was possible during the study to identify interns within the sample group that possessed relatively high degrees of linker or stabilizer tendencies. From the previous conclusion, one might surmise that the laboratories would have used these two groupings of interns in different ways in order to make best use of their respective talents in accomplishing the laboratories' research and development mission. There is, however, little evidence that the laboratories formally recognized the characteristics described by the linker-stabilizer concept and there did not appear to be any significant differences in the laboratories' utilization of these two groups.

The supervisors' evaluations of the interns' performance also did not show any significant differences between the linker and stabilizer oriented groups. One assumption that perhaps comes too easily to mind when considering the linker-stabilizer characteristics is that one group is likely to be superior to the other in some of their performance or output traits. The results of this study do not support that assumption however and one might speculate on the possible reasons as follows:

1. The one-year performance period may not have been sufficient to allow the discriminating traits to emerge, be recognized, and be utilized.
2. Performance is not evaluated on some unique, absolute scale, but is more an interpretation of the employees' performance as seen through their supervisors' eyes, i.e., a supervisor with strong linker traits might value the same traits in his employees more highly than a supervisor having different traits.
3. The study may not have adequately discriminated between linker-stabilizer characteristics.
4. The interns may not be a typical group in terms of linker-stabilizer characteristics.
5. The elapsed time since the termination of the internship program and the study (ranging from one to two-and-a half years) tended to obscure the supervisors' recollection of the interns' performance.

The possible existence of one or more of the above factors, or some other unknown influencing factor, was not included in the scope of this study and therefore was not investigated.

In general, there did not appear to be an excessive number of barriers in the laboratories that would tend to discourage employees from submitting innovative suggestions. There was some indication, however, that individual laboratories that had specific types of barriers, such as lack of an open door policy by supervisors, were less likely to receive and use innovative suggestions from the interns. This trend was not strong enough to be considered conclusive.

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7. MEASURING THE EFFECTIVENESS OF A RAPID RESPONSE TECHNOLOGY TRANSFER PROGRAM

by

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Introduction

This paper describes a method that has been developed to measure the effectiveness of a technology transfer program. The method was used on an on-going Navy program and showed that benefits to Navy users amounted to almost $3 for every program dollar spent. The method was developed by two Civil Engineering Corps officers, LCDR Jack Hendrickson and LT Bill Fisher, and documented as a Naval Postgraduate School report in December 1974. It was their thesis for the degree of Master of Science in Management.

The technology transfer program described in this paper was funded by the Naval Facilities Engineering Command (NAVFAC) and executed by the Navy's Civil Engineering Laboratory (CEL) with the purpose of providing rapid response service on short term requests for technological assistance from Navy shore activities. The program is coordinated by CEL's Facilities Engineering Support Office (FESO).

It is also desirable to recognize some follow-on work by Professor Jolly who was a thesis advisor for this study. He let me read a draft of a related paper he was preparing and some of my wording may sound familiar to him.

There have been various efforts to measure the effectiveness of the Assistance Program. However, the need for a comprehensive method of quantifying benefits of this program have persisted. That need has now been satisfied by the evaluation method developed by Hendrickson and Fisher.

Outline

To set the stage, first some background on the Naval Facilities Engineering Command, its R&D program and its Technology Transfer programs: Then some background on the Civil Engineering Laboratory, its Facilities Engineering Support Office, and some details on the Assistance Program. This will be followed by some comments on the internal methods that have been used at CEL to evaluate program progress. Then there will be a discussion of the approaches previously used by the Naval Postgraduate School to evaluate the Assistance Program. Next will be presented the derivation of the evaluation model by Hendrickson and Fisher. This will be followed by the application of the model to the FY74 program data. Finally, the results of cost benefit analysis performed using the model will be shown. By approaching the subject in this way, the plan is to give you a feeling for the NAVFAC/CEL Assistance Program and the environment in which it functions. With that background, the discussions that follow on the development and exercising of the evaluation model will be more meaningful and allow you to relate these efforts to an effort or program that you might want to evaluate.

Organization and Mission

Figure 7–1 depicts the big organization picture and the relationship of two of the main players, the Naval Facilities Engineering Command and the Civil Engineering Laboratory. CEL is under the administrative control of the Naval Construction Battalion Center at Port Hueneme. CEL is a detachment of the Center, but in R&D matters CEL operates in a somewhat autonomous manner making direct contact with NAVFAC and others as necessary.

The Naval Facilities Engineering Command executes a program of Research, Development, Test, and Evaluation for shore facilities, Advanced Base and Amphibious Operations, Seafloor Structures, Environmental Control, and Energy Conservation. The part that is of interest today is related to shore facilities. NAVFAC's link to the shore facilities is primarily through their Engineering Field Divisions, their Public Works Centers, the Public Works Departments of individual Naval Activities, and the NAVFAC construction program offices, the

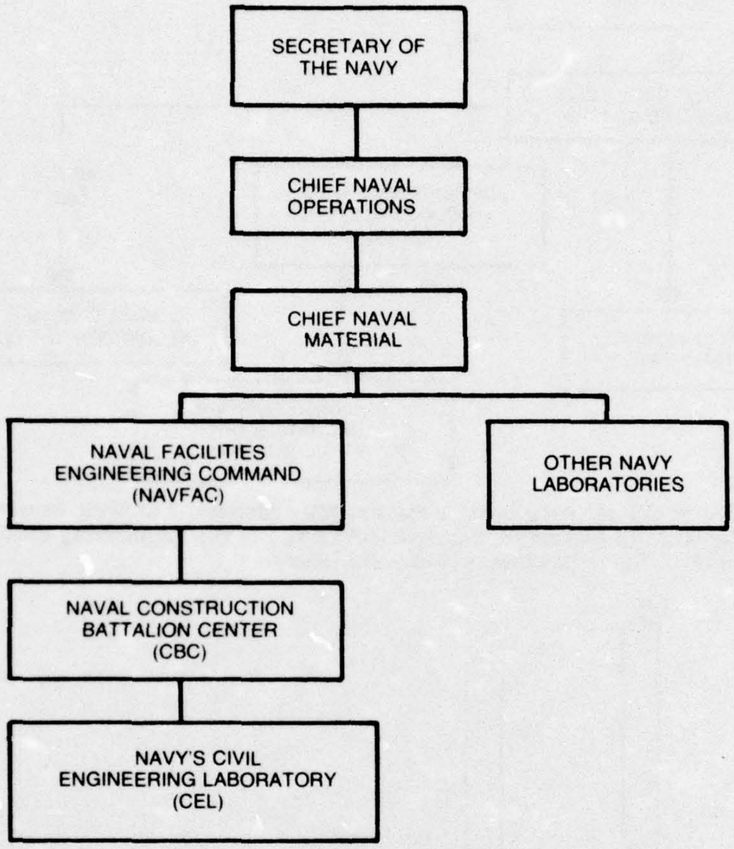

Figure 7–1 Command Organization. This diagram shows the relationship of the Naval Facilities Engineering Command (NAVFAC), the Naval Construction Battalion Center (CBC), and the Navy's Civil Engineering Laboratory (CEL).

Officer in Charge of Construction (OICC) and Resident Officer in Charge of Construction (ROICC). (See Figure 7–2). You will see and hear more about these field organizations later.

The mission of the Civil Engineering Laboratory is a reflection of NAVFAC's R&D mission: To act as the principal Navy RDT&E Center for shore and seafloor facilities support of Navy and Marine construction forces. The part that we will be looking at is related to shore facilities because the purpose of the Assistance Program is to provide assistance to shore activities. A major portion of the NAVFAC R&D program effort is assigned to the Civil Engineering Laboratory in the form of specific research projects. Figure 7–3 shows a breakdown of the FY1975 program by mission areas. About 65 percent of what you see is funded by NAVFAC with the remainder coming from other Navy, DoD, and non-DoD sponsors. A significant portion of the NAVFAC program accomplished at CEL provides R&D results which benefit the Navy shore activities in efficiently and effectively meeting their independent missions. These would primarily be in the areas of Shore and Harbor Facilities, Energy Conservation and Environmental Pollution Abatement.

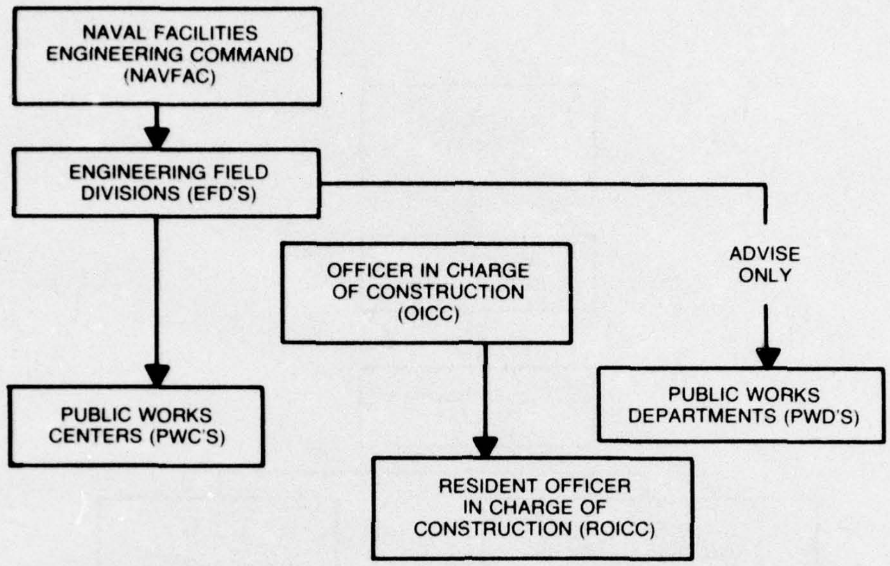

Figure 7–2 NAVFAC Relationships for Facilities Matters. The links between the Naval Facilities Engineering Command (NAVFAC) to the Engineering Field Divisions and other Shore facilities activities are shown.

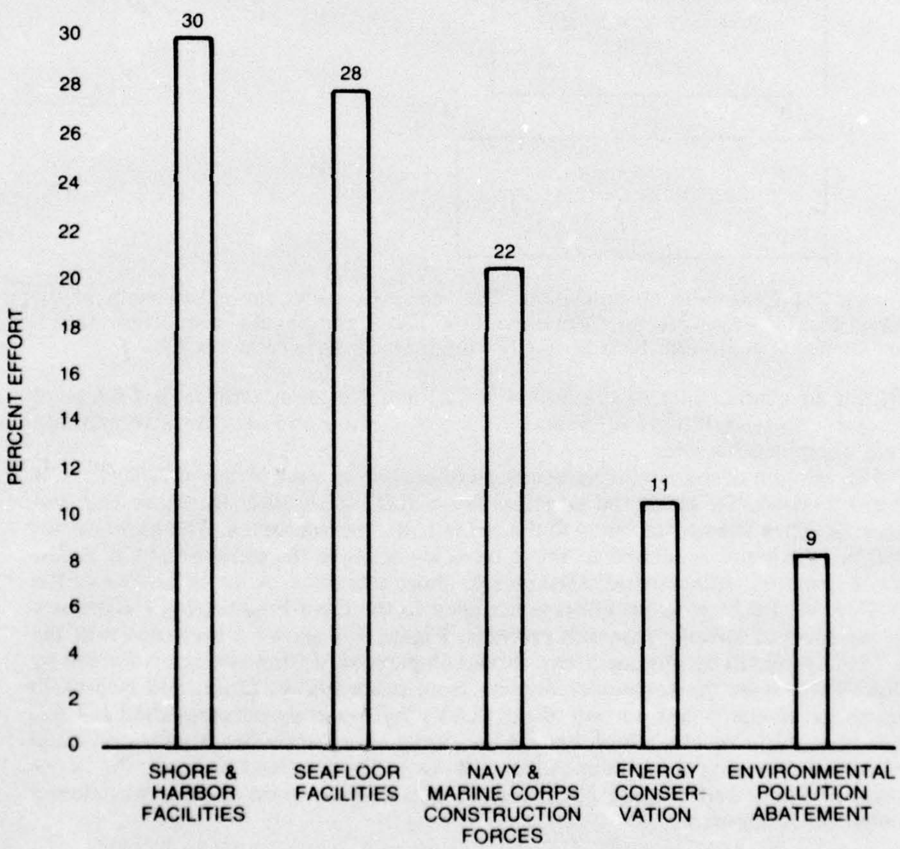

Figure 7–3 Funding by Mission Areas FY 75 Energy and environment have become increasingly important now amounting to about one-fifth of the CEL effort. Shore and Harbor Facilities remain the first priority.

At present, there are nine Naval officers, seven Navy enlisted and 300 civilians working at CEL. Five of the nine officers serve in administrative and liaison positions. The other four officers are involved in project work and the seven enlisted personnel are all divers assigned to the diving locker. The 300 civilians are scientists, engineers, and support personnel. The professional staff numbers about 150 people, or about half of the civilian complement, and is highly qualified in a large number of engineering and scientific fields. A tabulation of CEL disciplines is shown as Figure 7–4. This variety of disciplines makes our title of Civil Engineering Laboratory somewhat of a misnomer, but it's also what makes the Assistance Program work. This breadth of knowledge coupled with the professional experience of the staff makes a good combination for being responsive in a variety of subject areas. The professional staff is of very high caliber. All hold degrees, with over half holding masters degrees and another 20 percent with doctorate degrees.

ENGINEERS	SCIENTISTS
CHEMICAL	BIOLOGIST
CIVIL	GEOLOGIST
ELECTRICAL	CHEMIST
ELECTRONIC	METALLURGIST
STRUCTURAL	PHYSICIST
HYDRAULIC	OCEANOGRAPHER
MECHANICAL	OPERATIONS ANALYST
SANITARY	MATHEMATICIAN

Figure 7–4 Navy's Civil Engineering Laboratory Disciplines. Even though the name and mission emphasize Civil Engineering, it is necessary and desirable for the laboratory to have engineers and scientists that are qualified in a wide range of disciplines.

To round out the CEL picture, you need to know how we are organized and where the Facilities Engineering Support Office fits into the organization. This is shown in Figure 7–5. We have a military Officer-in-Charge and Assistant Officer-in-Charge and a civilian Technical Director. A number of support offices service the professional staff which is divided into four departments and offices displayed along the bottom. These are the people who actually provide assistance to people in the field. The Facilities Engineering Support Office, the official title for the one-man liaison office, is located as a staff to the Technical Director to have easy access, to any part of the organization. The FESO was established in June 1971 to emphasize management's desire to focus attention on the Assistance Program and to ensure the Laboratory responsiveness to field needs. Its primary functions are: To act as a point of contact for liaison with the field, To coordinate the Assistance Program, To identify user needs and influence the on-going research program, and To insure the application of results. The Assistance program is a NAVFAC-funded program operated by CEL. The program has been operating since 1963, but without the focus and coordination that was provided starting in 1971.

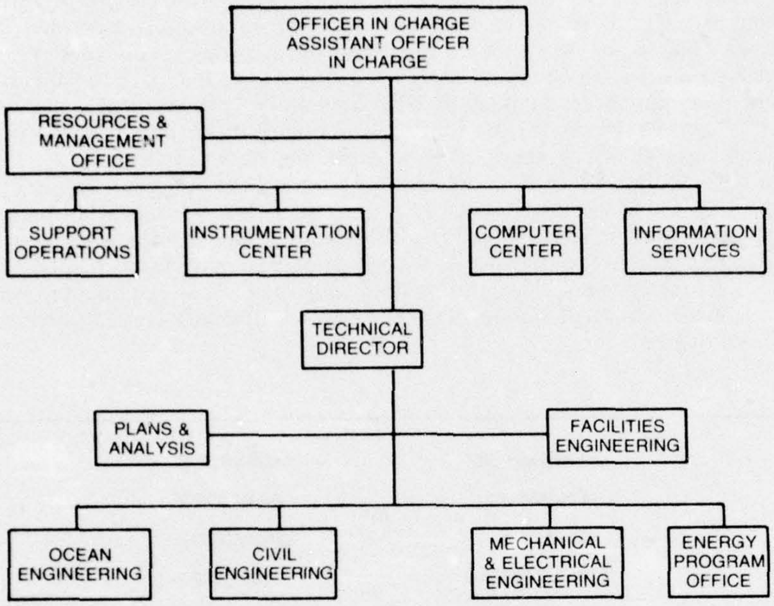

Figure 7–5 Internal Organization of the Navy's Civil Engineering Laboratory. The Facilities Engineering Support Office (FESO) is shown as a staff function to support the Technical Director. It serves as a liaison between the Field Engineering Offices of NAVFAC and the departments of the laboratory.

Assistance Program

Here is a brief summary of the Assistance Program and the part played by the FESO office. A man in the field with a problem or a need for information relating to new materials, equipment, techniques, and maintenance or construction procedures requests assistance from the Laboratory. The FESO provides the necessary liaison and coordination to ensure that he gets a quick answer, at no cost, because the program is prefunded by NAVFAC. The Assistance Program involves efforts to directly transfer technology from its origin to its usage in response to specific situations or problem areas that are brought to the attention of the FESO by potential users in the field. Action starts when someone in the field makes a request for assistance. This effort of FESO is shown by Figure 7–6. Another NAVFAC Technology Transfer program is called the RDT&E Liaison Program. This is shown schematically as Figure 7–7. In each of the six EFDs, an RDT&E Liaison representative has the collateral job of providing liaison between NAVFAC and the field in the R&D area. They transmit to NAVFAC expressions of need for R&D in specific areas based on field needs they see. They also pass the results of R&D related to field problems, and needs, to people in the field. These are the same field people that the Assistance program serves: The 6 EFDs themselves, the 9 Public Works Centers, the Public Works Offices at 180 odd independent activities and 83 NAVFAC construction offices. Both programs are trying to help the same people, although in different ways. This results in a multitude of communication channels.

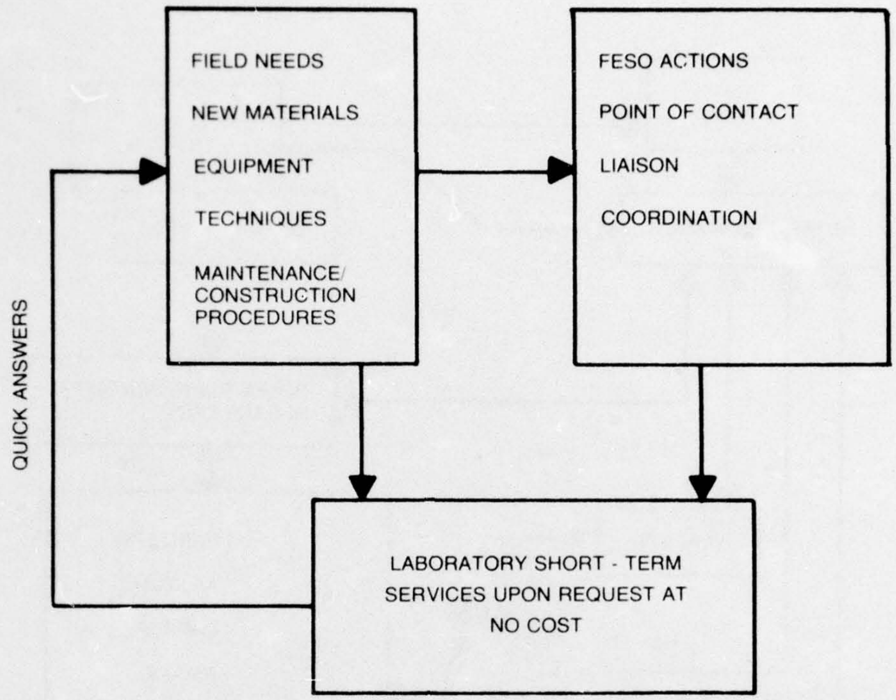

Figure 7–6 Field Needs and FESO Action. The FESO acts as the liaison in terms of assuring quick answers to field needs.

Evaluation of Assistance Program

As a prelude to the evaluation work done by the Postgraduate School, Figure 7–8 gives some highlights of the Assistance Program as measured by CEL. Since the Facilities Engineering Office was established in 1971, we have been measuring progress or usage by two main parameters: Namely, the number of requests we receive for assistance and the number of activities that request assistance. Growth in usage of the Assistance Program has been encouraging by both measurements.

The subjects of these Assistance requests are as varied as the disciplines of our professional staff. Figure 7–9 shows the subject area and the relative percentage of importance for the FY74. The top subject area of paints, coatings and chemicals has been consistently around 25% for the last three years. The energy area was a new entry for FY 74. Almost half of the requests come from the Public Works Offices. When we started keeping track of the program, the bulk of the requests were coming from the Engineering Field Divisions, but that trend reversed several years ago. Figure 7–10 is a graph showing the number of requests for assistance made to the Navy's CEL by each of the activities. The FESO claims that it is easy to reach, right at the other end of the telephone. In fact, the telephone is equipped with a 24-hour answering service. The telephone must be satisfactory for requesting technical assistance because 76 percent of the requests received last year were received by telephone.

A natural question at this point might be—How fast is our quick response service? Our scorecard is shown on Figure 7–11. Over half of the requests received in fiscal year 1974 were satisfied within a week of receipt and a total of 75 percent within a month. People just aren't accustomed to thinking of this kind of

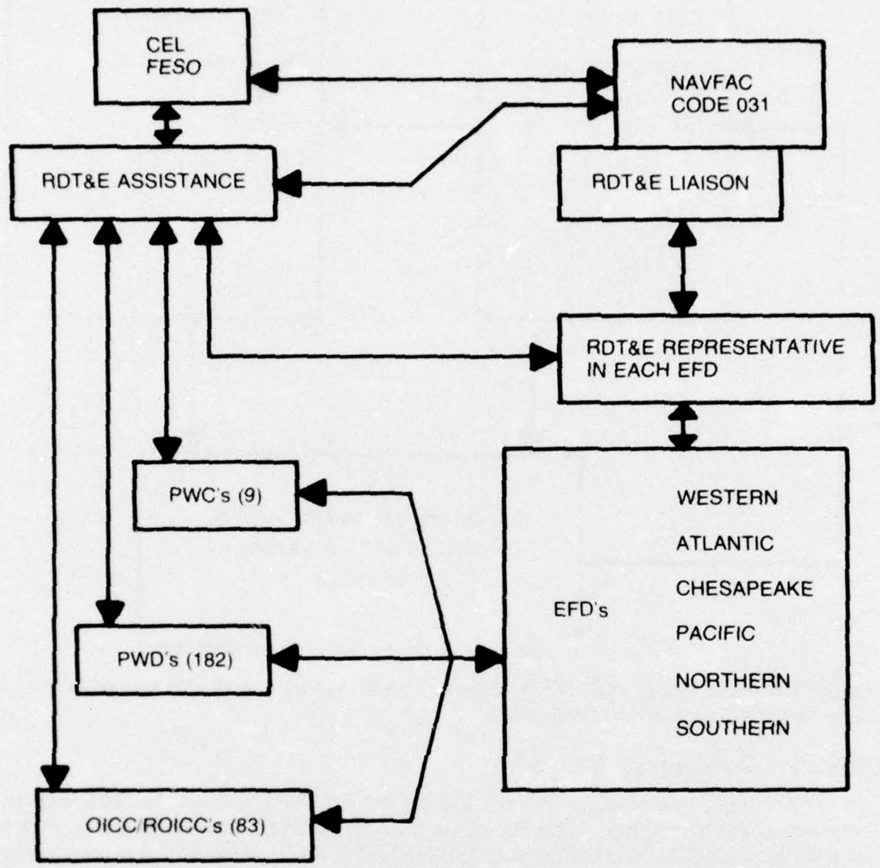

Figure 7–7 NAVFAC RDT&E Assistance and Liaison Programs. The Liaison activity forms a three way communication network that ties together the NAVFAC, The Navy's CEL and the Engineering Field activities.

reaction time when they think about a research laboratory. It is the way to assure continued use of an assistance program.

What benefit is there in all of this for the user? The measures CEL normally uses speak to system usage and response time. Increased activity and rapid response time are both good—but they do not measure the benefit to the user. In response to a NAVFAC desire to measure these benefits, and to measure them quantitatively, the Naval Postgraduate School started looking at the Assistance program in 1972. An effectiveness questionnaire was developed and was completed by the EFD liaison representatives for the requests that originated from the EFDs. The evaluation process was continued the next year for the FY 73 Assistance Program with a slightly modified questionnaire which was again completed by the EFD liaison representatives for the requests that came from their EFD. Evaluation of the returns from these two years of evaluation yielded a variety of interesting statistics and trends, but the most dramatic result was the realization that a better method of measurement of the benefit of this type of information was necessary. The evaluation of benefits using the questionnaires was too restrictive.

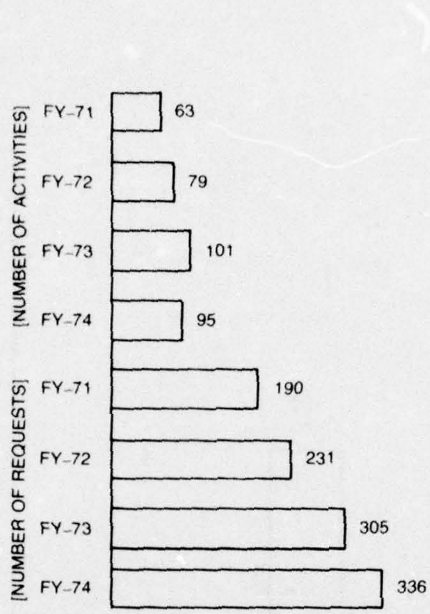

Figure 7–8 Activity Requests by Year from Field Organizations. The trend toward more use of the Navy's CEL is shown by the increase in the number of service requests from the field to the laboratory.

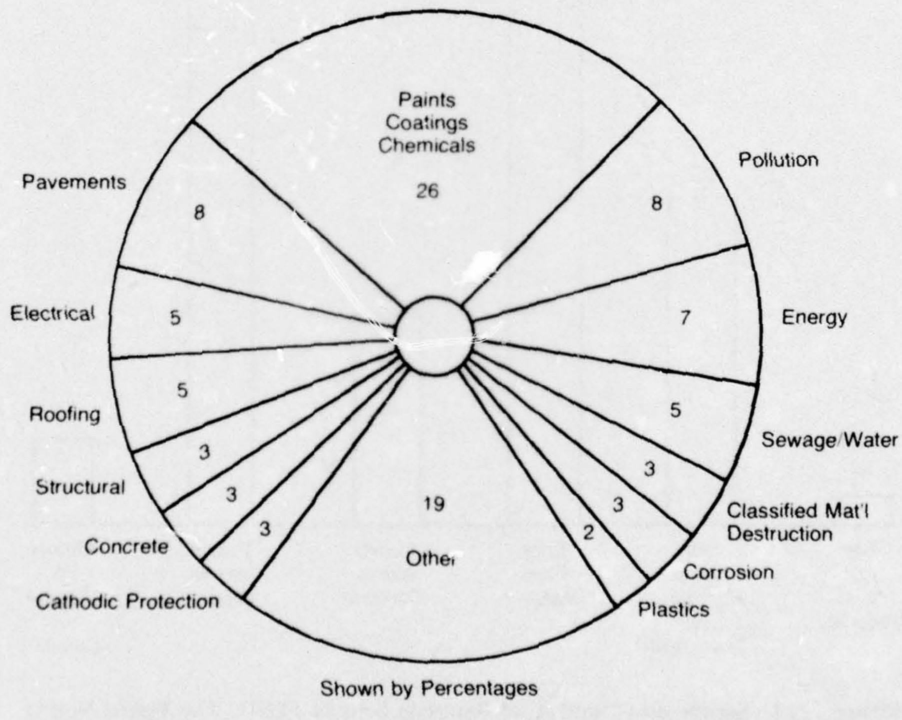

Figure 7–9 Subjects Covered by Requests. The requests for information originating in the field and sent to the Navy's CEL tend to cover a very wide spectrum of subjects.

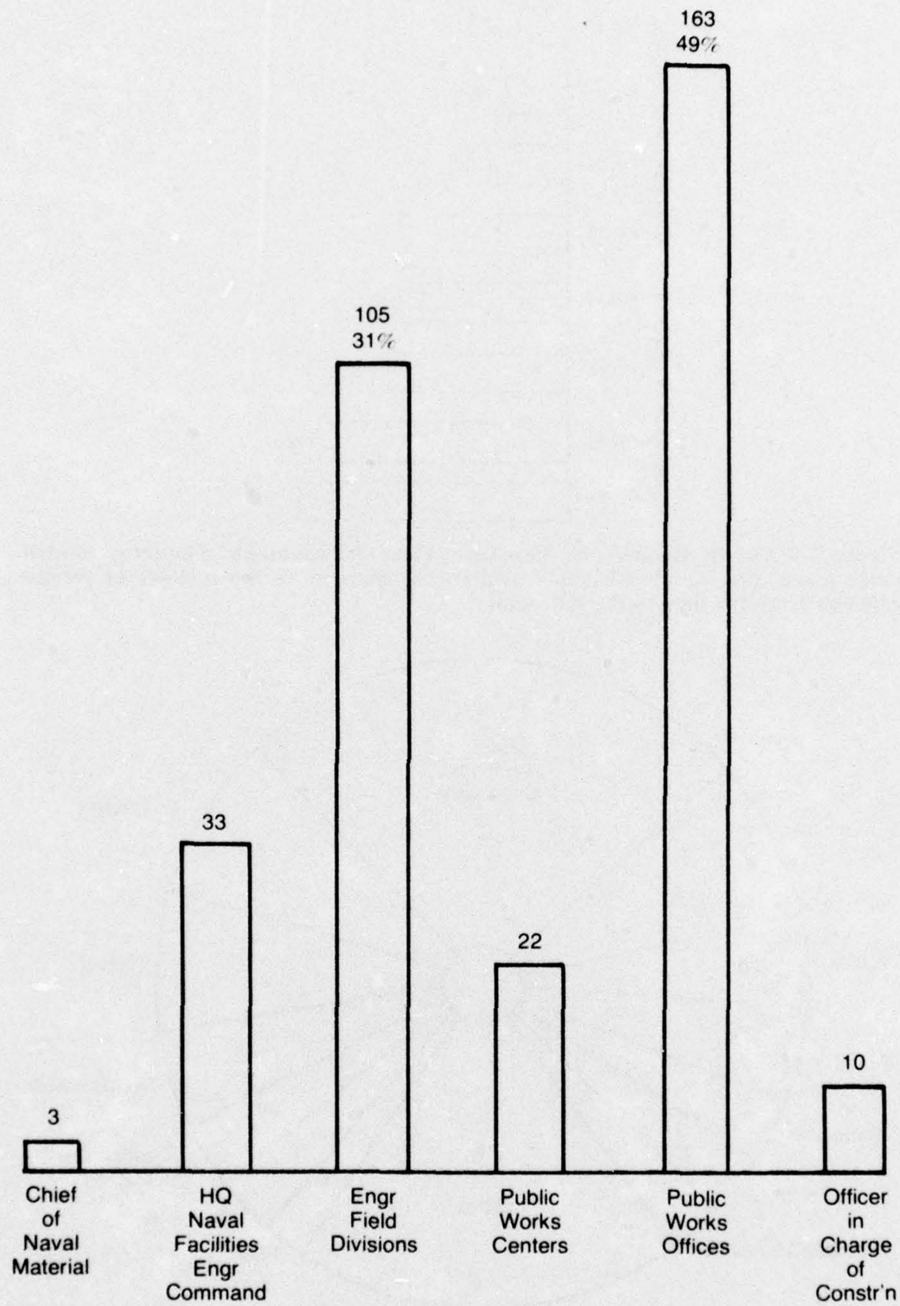

Figure 7–10 Source and Number of Requests Sent to FESO. The Public Works Offices and the Engineering Field Division Offices together account for over 80% of all requests for assistance sent to the Navy's Civil Engineering Laboratory.

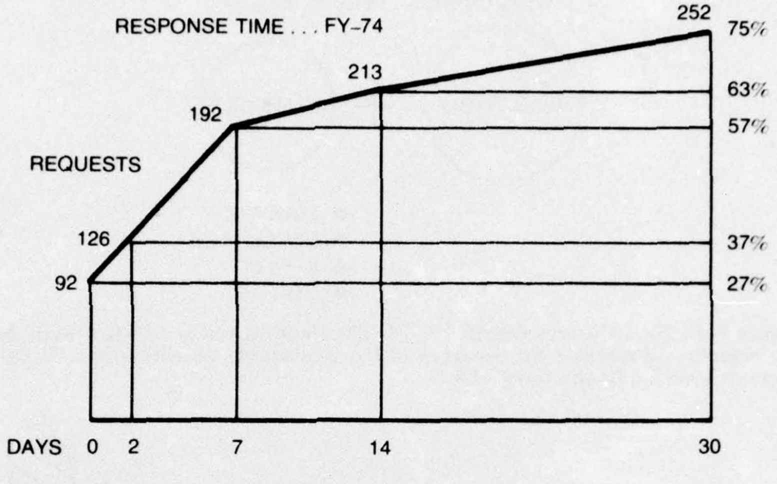

Figure 7-11 Response Time to Requests for Assistance. The Navy's Civil Engineering Laboratory has been able to respond to 57 percent of the requests received in seven days or less.

It only permitted benefits to be classified into two main categories: Specific dollar savings and intangibles. The net effect was that the intangible benefits were several times larger than the benefits quantified in dollars. The intangible benefits, which were not measured, far outweighed the measurable benefits to the point that it was believed that the Assistance program benefits were not being accurately measured. It made the need for a better method of measuring benefits even more important.

Improved Measuring Methods

If the analysis were to have real meaning, the intangibles or unmeasurable category would have to be narrowed to a level where its uncertainty did not overshadow the measurable category. Figure 7-12 depicts the objective of the Hendrickson and Fisher study. One way that a more accurate measure of benefit could be achieved was to extend the survey to include more of the field requests. The 1972 and 1973 surveys were limited in scope, the 85 and 104 requests surveyed in those years were from the Engineering Field Divisions only. This did not give a representative sample of the total population. Figure 7-13 shows the detail of the sources of requests for assistance.

Only a small fraction of the requestors that completed the questionnaire were willing to assign a dollar value to their use of the CEL assistance. In FY72 only 12 of the 85 requests surveyed, or 14½ percent, gave dollar values. It was somewhat better in fiscal year 73 when 30 percent gave dollar values. Even so, it was felt that the true value of the benefits were not being evaluated by the questionnaires that were being used. For the FY74 survey, Hendrickson and Fisher selected 295 requests for analysis, thus extending the survey to include all of the field requests. A revised questionnaire was also developed. Again the EFD liaison representatives completed questionnaires for the requests that had come from the EFDs. Information on the remaining 190 requests from PWCs, PWOs, OICCs, and ROICCs were gathered via telephone by researchers at the Postgraduate School.

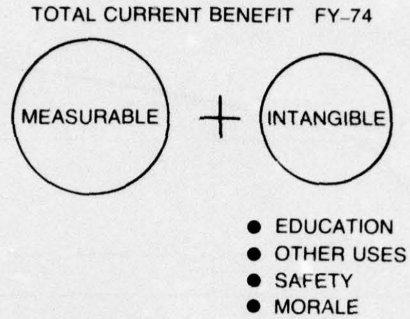

Figure 7-12 Total Current Benefit FY-74. The Hendrickson and Fisher Study had the objective to increase the accuracy of the measurable benefits from assistance requests received by the Navy's CEL.

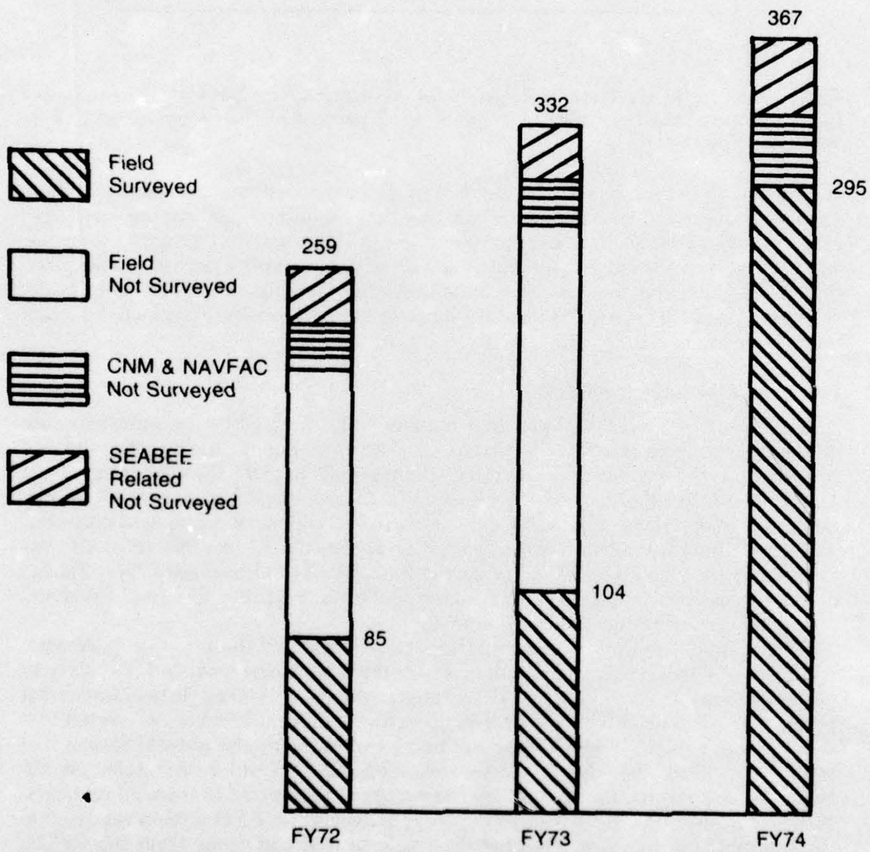

Figure 7-13 Source of Requests and Number Surveyed. In FY-72 and FY-73 the survey was limited to the EFD's. The term "Field" includes both EFD's, PWC's, PWO's, OICC's, and ROICC's.

The same questionnaire was used in obtaining information over the phone as was used by the EFD representatives.

Before the revised questionnaire was developed and used, Hendrickson and Fisher did some deep thinking about why the last two surveys had not given the desired information. One of the first things they recognized was that by looking at current benefits they were only looking at part of the picture. There were actually two kinds of benefits: PRESENT AND FUTURE. The current benefit of the Assistance Program is that realized by someone in the field as a result of the assistance provided in response to their request. It was decided to limit the study to current benefits as had been the case in the other two Postgraduate School studies. However, in passing, some attention was focused on the fact that the Assistance Program would produce future benefits. The primary benefit was through this exposure to field problems, CEL's ongoing research program would become more aligned to the real needs of field users. Thus common problems, those faced by a number of Activities, would surface sooner and solutions to these problems would become available at an earlier date to provide the basis for improved efficiencies and performance.

Probably the most important thing to recognize was that objectively quantifying the benefits of the CEL Assistance efforts would be highly subjective and lead to varying results. For example, the benefit of a specific recommendation to solve a particular problem can easily be quantified if it will reduce out of pocket expenditures to achieve identical results. Quantifying benefits derived from one piece of information which is only part of the total information, required to arrive at a decision, involves a greater degree of subjectivity. At the extreme end of the scale, quantifying intangible benefits such as increased morale, safety and general information would involve the most subjective measurements of all. In essence, any attempt to quantify the benefit of information is necessarily highly subjective and recognition of this fact was an underlying consideration in the development of a new approach.

New Approach

The major issue in evaluating the benefit from a technical recommendation was to develop a categorization process. A system was needed that would provide an organized method of testing to see whether or not a benefit resulted, and if a benefit resulted, then to what extent the recommendation was responsible for the final benefit. The categorization system developed for evaluating benefits looked like Figure 7-14. The first thing to find out was whether or not the requestor considered that the assistance he received was in any way beneficial. This information was obtained by revising the questionnaire and placing this straightforward question at the head of the list.

Assuming that there was perceived benefit—the evaluation continued. The next three steps in the categorization process looked into: (1) The type of assistance or

—BENEFIT? YES OR NO
—TYPE OF INFORMATION
—% CONTRIBUTION TO DECISION
—PROBABILITY OF IMPLEMENTATION
—ESTIMABLE? YES OR NO

Figure 7–14 Evaluation of Benefits. The levels of categorization are shown. Each request for assistance could be subjected to evaluation by determining the answers to the questions shown.

information provided, (2) A determination of the percentage of contribution of the recommendation to the final project decision, and (3) The likelihood that the project would be implemented so that the assistance would actually produce a benefit. The final steps in the process were to determine whether or not a specific dollar benefit could be estimated and calculate the actual benefit.

The three central steps in the process will be discussed in a little more detail before exposing you to the whole model.

(1) TYPE OF INFORMATION

The evaluation with regard to the type of information was fairly straightforward. The choices were whether the information was general in nature, so as to have no immediate value that could be identified, or whether the information was specific to a project or use and therefore of current benefit.

(2) PERCENT CONTRIBUTION TO DECISION

The next stage in the evaluation process was to determine whether the specific information was essentially complete and self-contained in terms of influencing a decision to do something, or whether the information provided was only part of the total information used to arrive at a decision. In these cases where the information was complete 100 percent credit for the benefit was allocated to the Assistance Program. Where the information provided was used in conjunction with other information already available to the user, an information percentage factor was used which varied between 1 and 99 percent. The factor was determined on an individual case basis.

The assigning of these information percentage factors was recognized to be subjective, and not wholly accurate, but certainly more correct than giving the Assistance Program 100 percent credit for information which was incorporated with other information already known by the requestor.

(3) PROBABILITY OF IMPLEMENTATION

This stage in the categorizaton processs involves the determination of the probability that the recommendation or information provided would be implemented. Here, results that were considered beneficial were classified into one of the four categories shown in Figure 7-15. Probabilities were assigned to the last three categories based on the experience of the investigators. The first category needs no factor since implementation represents 100 percent credit for the Assistance

PROBABILITY OF IMPLEMENTATION

	RANGE	MEAN
IMPLEMENTED	1.0	1.0
PLAN TO IMPLEMENT	0.4 - 0.6	0.5
DELAYED PLAN (TEST)	0.2 - 0.4	0.3
DELAYED PLAN (STUDY)	0.1 - 0.3	0.2

Figure 7-15 Probability of Implementation. The assigned probability was based upon the action plan. An implementation plan was assigned a probability of 1.0 while a delayed study plan had a low probability of 0.2.

Program. The least subjective category, where there was a definite plan to implement the information, was assigned a probability of .5. It was felt that this estimate could be inaccurate to the degree that figures could vary anywhere in the range of .4 to .6. The last two categories involved "ifs". The project would be planned for implementation if tests proved successful, or in the last case, if studies showed this to be the proper course of action. Probabilities of implementation were determined in a similar manner to those for the planned projects. The subjectivity of the estimates increases and therefore the probability of implementation decreases as you proceed from plans to test to study.

Model

Now that the basic parts of the model have been presented, it is logical to present the complete model. This is shown as Figure 7–16. Everything except the heart of the benefit analysis, dollars, has been discussed. Consider those cases in

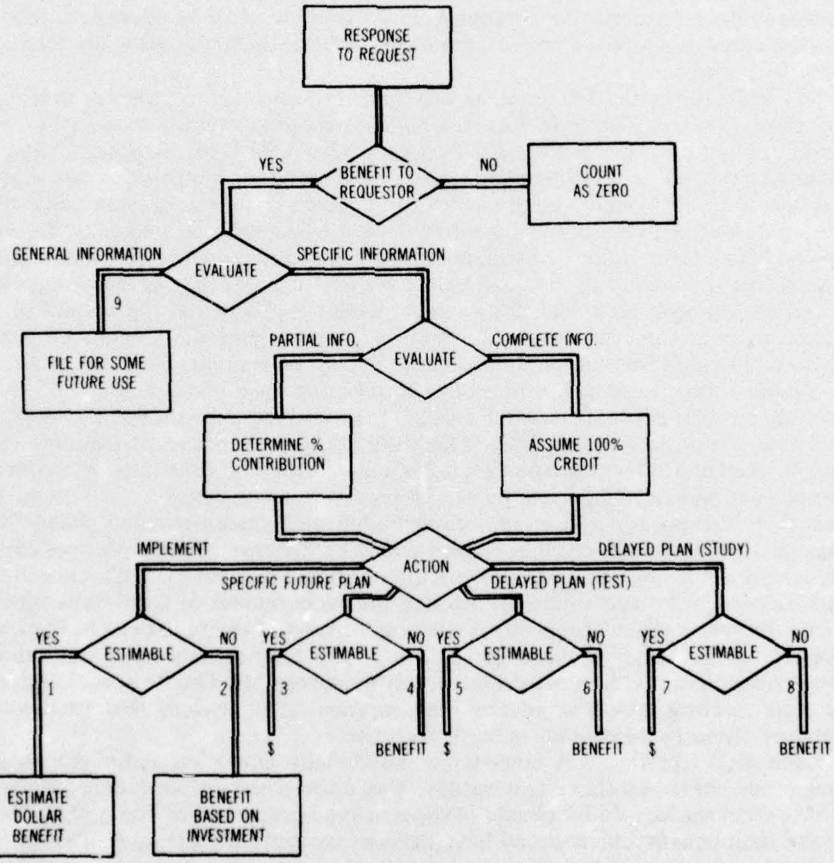

Figure 7–16 Benefit Evaluation Decision Model. Starting at decision A, a series of decisions are shown that make it possible to evaluate the dollar benefit of the answer to a technical question supplied to an engineering organization by a research laboratory.

the bottom row where a YES indicates that a dollar estimate of benefit is possible. That's the odd numbers—1 through 7. If the estimated savings were of the one time type, the amount identified was used as the project benefit dollar base. If the estimated savings were of the reoccurring type, then the present value of the first five years of savings was used as the project benefit dollar base. The benefit credited to the Assistance Program in both cases was the project benefit dollar base reduced as necessary by the factor for information contribution and the factor for implementation probability. The cases where NO indicates that a dollar estimate of benefit is not possible, which are the even numbers from 2 through 8, represent recommendations which did *not* result in specifically identified dollar savings. These generally fell into areas where the benefit was in the form of improved operations, better morale, increased safety, improved quality, etc. In the FY72 and FY73 surveys these benefits were left as unquantified intangibles and they outweighed the measured benefits. But with the exception of information which fell into the general category that was not quantified, that would be number 9 in the upper left area, each response to a request should have an identifiable benefit even though it may not be readily quantifiable in terms of direct dollar savings. Each response to a request could in some way be identified with an implemented or proposed project, the magnitude of which was normally relatively easy to estimate.

In FY 74,100 of the 295 requests evaluated fell into this inestimable category. For these cases an additional factor, a benefit percentage factor, was applied as a further reduction. The assumption accepted at this point is that in order to commit funds to a project, a decision maker must, whether he recognizes it or not, expect a return in future benefit which is some percentage greater in present value than the initial outlay. This percentage would vary from decision maker to decision maker. Even though the investment return would be expected to vary, it is assumed that the quality of the decision maker who decides to implement a project based on supplied technical information, would be such that the results of his decisions over the long run would yield a positive benefit. It appeared that a reasonable value for this factor would be 0.1 or 10 percent. This would be the minimum return expected. For example, take the case of a modification to an existing piece of equipment which would result in some unquantifiable benefit. In this case, the project benefit dollar base would be the cost of the modification. The benefit credited to the Assistance program would then be calculated by reducing the project benefit dollar base by the 10 percent benefit factor as well as by the necessary factors for information contribution and implementation probability. One of the most complicated examples would be the case where a piece of equipment was due to be replaced and the information provided by CEL caused the replacement to be accomplished through the procurement of a different type of item which was more beneficial. Assuming the cost of the replacement item was essentially the same as the original, use of the total procurement cost as the project benefit dollar base would be clearly inappropriate. On the other hand, use of a zero benefit would be just as inappropriate. It is obvious that some value between these two extremes is more accurate.

Each case like this was considered individually and a value for the project magnitude, between these two values, was chosen subjectively considering to what extent the non-dollar benefit of the new type procurement increased relative to the total benefit which would have accrued by replacing the item in kind. The percentage increase in benefit was applied to the cost of the procurement and that figure used as the project benefit dollar base. Again, the benefit credited to the Assistance Program was calculated by reducing the project benefit dollar base by applying the 10 percent benefit factor as well as by the necessary factors for information contribution and implementation probability.

Quantified Benefits FY 74

Application of the model to the 1974 survey data produced the benefits shown in Figure 7–17. Of the 295 responses surveyed, 233 indicated that the requestor considered that he had received beneficial information or assistance. That is 79 percent, a very satisfying number. There were 62 cases indicating that the request yielded no beneficial information. However, among these were 40 cases in which extraordinary circumstances indicated that the cases should not be included as zero benefit requests, but rather should be eliminated from the sample for purposes of cost benefit analysis. These are shown as not counted. That leaves only 22 cases where requestors said they did not receive any benefit.

BENEFIT CODE	REQUESTS	MEAN VALUE
NOT COUNTED	40	
ZERO BENEFIT	22	
1	27	$254,361
2	51	18,525
3	6	19,250
4	38	29,540
5	8	62,534
6	8	10,455
7	1	472
8	12	2,130
9	82	unquantified
	295	$397,267

Figure 7–17 Quantified Benefits for FY–74 FESO Operation. Dollar benefits are shown according to benefit code. The dollar benefits are calculated using the Benefit Evaluation Model.

The remainder of the table shows the benefit code numbers which correspond to the numbers we just talked about on the model, the number of requests, and the total benefits calculated for each benefit code number using the factors previously presented. Although three values for benefit were developed for each benefit code, only the mean values are listed for clarity. Note that there are still 82 unquantified requests in the general information category. Although the requestor said he received benefit, no effort was made to establish dollar benefit value for general information which may have been filed for future use.

Cumulative Benefits

A cumulative plot of all the information developed is much easier to look at and some interesting observations can be made. This is shown as Figure 7–18. The curves graphically show that as the benefits of a greater percentage of requests in the sample are quantified, the total estimate of cumulative benefits becomes more subjective. The vertical distance between the HIGH and LOW curves at any point on the horizontal scale represents the range within which the estimates could reasonably be expected to vary due to differing personal values of estimators and decision makers. The curves also tend to intuitively verify the application of the model. The benefits from the highly intangible cases, like benefit codes 7 and 8 are less than those from the tangible ones, like codes 1 and 2, as indicated by the slope of the curves. Since the original objective was to quantify benefits in terms that are easily understood and appreciated by management, dollars that is, what does all this mean?

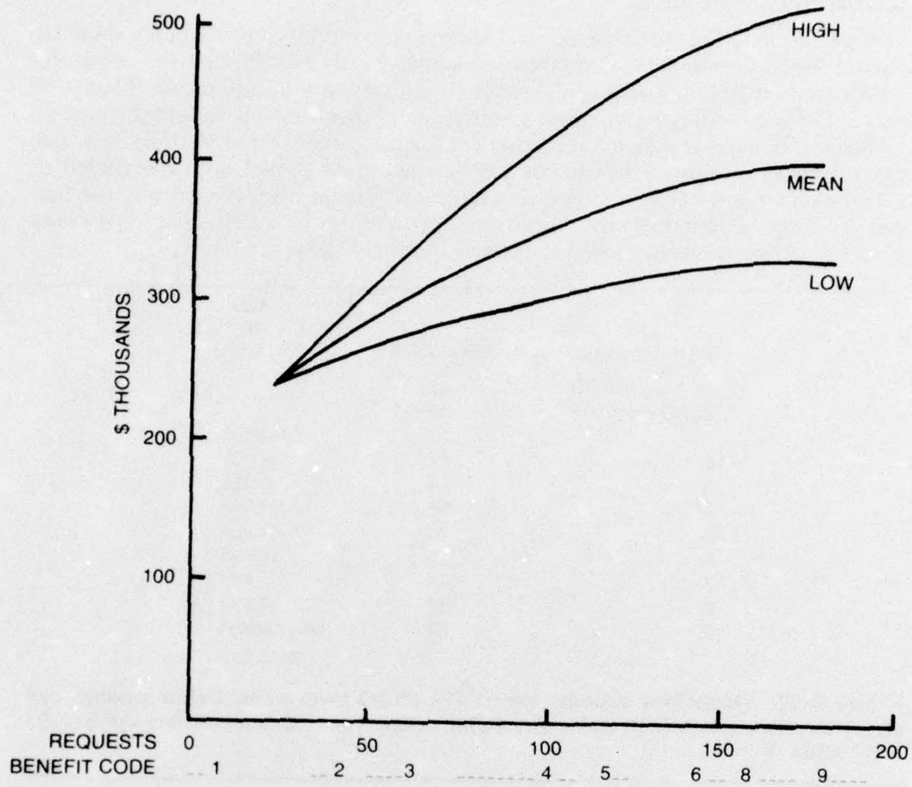

Figure 7–18 Assistance Benefits vs Number of Requests Ordered by Probability of Estimate. This figure shows the curves of quantified benefits utilizing high, mean, and low probability of implementation. The slope decreases and the range of accuracy widens as greater numbers of requests in the sample are quantified.

Return

The benefits divided by the costs gives the benefit per dollar spent. This is shown in Figure 7–19. Very simply stated, for every dollar we spent on the Assistance Program in fiscal year 1974, some user in the shore facility community realized $2.72 worth of benefit.

$$\text{RETURN} = \frac{\text{BENEFIT (MEAN VALUE)}}{\text{ASSOCIATED PROGRAM COST}}$$

$$= \frac{\$397{,}267}{\$146{,}093}$$

$$= 2.72$$

Figure 7–19 Program Benefit to the Navy. When the total dollar benefit for FY–74 is divided by the total program cost for FY–74 it shows a benefit to the Navy of $2.72 for each dollar spent.

Benefit Trends

One more interesting thing that was done as part of the FY74 survey was to take a backward look at the FY72 and FY73 data. The FY72 and FY73 benefits were classified as largely intangible and the intangibles were not measured. As such they far outweighed the measurable benefits such that the Assistance Program looked like a losing proposition, when intuitively this was not the case. A backward look at benefit trends using the methodology developed by Hendrickson and Fisher produced different results. The benefit trends for a three year period are shown as Figure 7–20. The first thing that should be noted is that benefits using the FY74 survey methods are about 3 times larger than those using the FY72/73 survey methods. What this means is that the results in 72 and 73 were understated at about one-third of their value. If you notice that the FY 74 dollar benefit is much smaller than previously shown, it is because to do this trend analysis certain extraordinary benefits were eliminated from the projections. There was one instance of a $150,000 saving in FY 73 and another in FY 74 that amounted to almost $188,000 that were not included. Also these FY 74 benefit figures were developed using an adjusted 40 percent sample to match the size of the sample that was surveyed in 72 and 73.

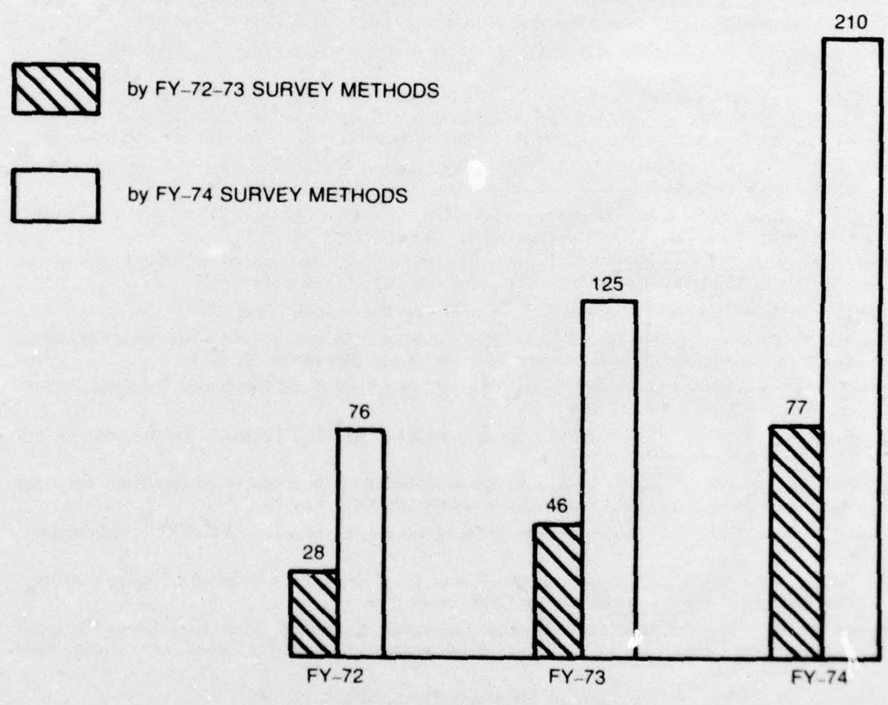

Figure 7–20 Assistance Benefit Trends (thousands of dollars). The bar graph shows the Navy's CEL assistance benefit using (1) estimates of the requestors and (2) using estimates from the Benefit Evaluation Decision Model.

Summary

This study has carried the cost/benefit analysis beyond the usual comparison of numbers of requests, response time and estimates of tangible benefits. A benefit

evaluation decision model was introduced that provided the means of categorizing technical information and recommendations. The model considers both tangible and intangible benefits. After the technical information or recommendations are categorized and a project dollar benefit base assigned, the dollar benefit is adjusted according to the percent of influence it had upon the project and the likelihood that the project would be implemented.

When the model was used to evaluate assistance responses over the last three years a noticeable increase in benefits was apparent. The evaluation of the FY 74 Assistance Program showed a return of $2.72 for each dollar spent.

Conclusion

This study demonstrated that it is possible to quantify meaningfully, in dollars, a significant portion of the benefits of technical information and assistance that are often identified as intangibles. This benefit evaluation decision model should be as useful in evaluating the benefits of technology transfer and utilization in other organizations as it has been in the Navy's Civil Engineering Laboratory.

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8. A STUDY OF THE TECHNOLOGY TRANSFER CAPABILITY OF ELEVEN ORGANIZATIONS

by

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It's a pleasure to be here this afternoon to be able to report on some research that we think is very interesting and hopefully will have some long term benefits. Before I become involved in the details of the research I do have some concerns that I want to express. When one gets into the area of research that involves a behavioral change and the measurement of organization performance it is certainly appropriate that one proceed very cautiously. At this stage it is very early in our research. Our findings have not been validated. In fact, our findings should be considered tentative and unproven at this period in time.

This is the one paper presented today in which there has been no prior published article, thesis, or report. This is mainly true because this research is in the early stages.

In order to fully understand the research work that I wish to discuss it is important that we have a common understanding of what is meant by technology transfer. Going back to Gilmore's (1969)[1] definition as the reference point we find that technology transfer is:

> "—a purposive continuous effort to move technical devices, material, methods, and/or information from the point of discovery or development to new users."

One main emphasis that I like to place on technology transfer is that it is a new use of existing information. It is not important whether the idea is new, only that it is new to the person adopting it. This is the important aspect.

Another main emphasis that I would like to place on technology transfer is that we analyze what we are really trying to accomplish. To make myself clear, I should like to go back to the definition of diffusion. This may give a worthwhile insight. Diffusion is the historic unplanned movement of technological devices, material, methods, and/or information from the point of discovery or development to a new user.

In the case of diffusion there is no focused effort to cause the transfer function to take place.

It has been published in the literature, and many of you know, that the diffusion process on the average takes about 30 years. It is very slow. Stated in another way, only about 3% per year of new technology moves to secondary users unless there is purposive effort. Because of this there is a great need for us to do something to speed up this process.

The third major emphasis that I would like to make concerning technology transfer is that it is a social process. This is illustrated in a statement by Havelock (1971):[2]

> "The transfer mechanism is not merely a series of communication channels through which information flows. It is a complex mechanism which involves the interaction of people."

This in no way detracts from the necessity or importance of documentation or distribution. It goes beyond documentation and distribution to the extent that technology transfer is also a people oriented concept.

The objective of the research that I will present here is to attempt to measure the differences in performance between organizations that accept technology movement and utilization simply as a diffusion process as contrasted to organizations that make a purposive, conscious effort to communicate and utilize knowledge.

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[1]Gilmore, John S. "The Environment and the Action of Technology Transfer: 1970–80," in a Report of a Conference sponsored by Denver Research Institute, University of Denver called Snowmass-at-Aspen, Sept. 26–28, Washington, D.C., Dept. of Commerce N70-26339, 1969.

[2]Havelock, R. G., *et al., Planning for Innovation Through Dissemination of Utilization of Knowledge*. Ann Arbor, Michigan: Institute for Social Research, University of Michigan, 1971.

Our desire was to see if it was possible to differentiate between two organizations with these different characteristics.

Earlier in the morning there was a presentation by Mr. Essoglou[3] that dealt with the 'linker concept.' It was interesting that the results he reported indicated that in fact there is very little difference in the distribution of the number of linkers or the number of stabilizers in any large organization. With this in mind, one wonders if it is possible to identify differences in characteristics between large organizations that might be effective in terms of technology transfer and those that might be relatively ineffective.

This study is intended to evaluate this organization difference. The presentation of the research study will be ordered as follows:

1. A review of the factors that are important in enhancing technology transfer.
2. A discussion about the development of the instrument for measurement of the selected characteristics of an organization.
3. A discussion of the results of the measurements.
4. A summary and interpretation.

I will be able to go through the model of technology transfer, Figure 8–1, very rapidly. You remember that Mr. Essoglou[4] used this model in his discussion. He talked about the transfer mechanism and the concept of movement of technology from the source to the user. This model was developed first by studying the literature. The literature search gave us a relatively long list of factors that are important in terms of enhancing the movement of technology from the source to the user. The large list was then distilled by using a modified Delphi process to arrive at the nine factors that you see in the model. Because of time limitations it would not be desirable to spend very much time talking about each element of the model, but in order to understand the research that I am going to discuss, some appreciation of the definition and scope of each of the nine factors is important.

Factor 1. The method of information documentation. Documentation deals with how the technical information is recorded and presented. Information documentation can be rated by considering the format used, how the material is organized and the complexity of the language. It is also necessary and desirable to design the documentation such that it is relatively easy to index and/or include in technical search systems.

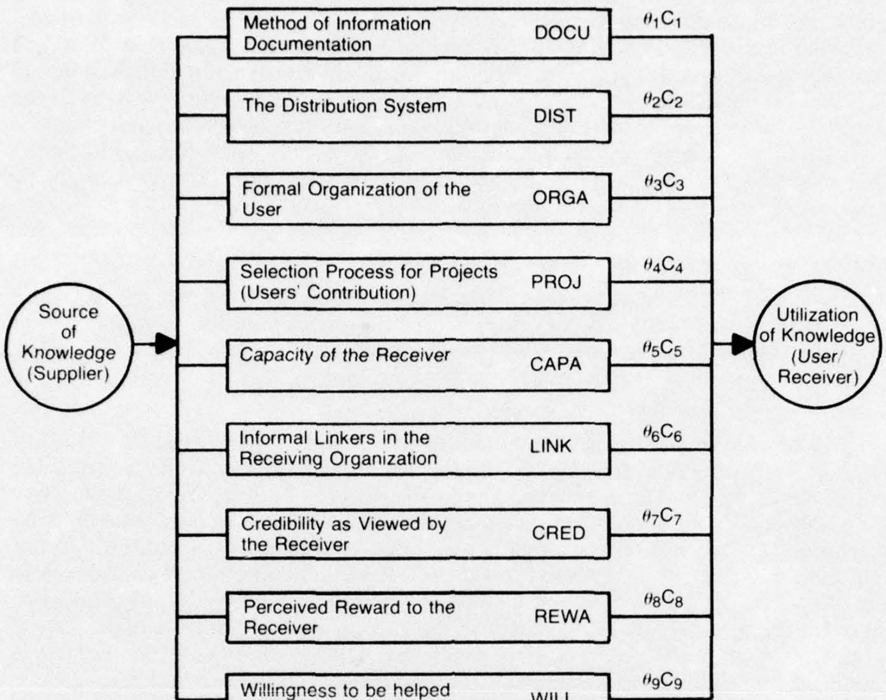
Factor 2. Distribution. The distribution as considered for this model is the physical channel through which technology flows. It involves both the number of entries and ease of access as well as the formal distribution plan. Distribution of technical information includes formal distribution lists, publications in journals, presentations at symposia and conferences, and person-to-person exchange.

Factor 3. Organization. This is the receivers perception of his formal organization. When trying to evaluate the formal organization, in terms of its influence on the utilization of technical information, it is useful to consider the infra-structure elements such as the power structure, the nature of the business, the management style, the resources available, the attitudes of management, the amount of bureaucratic tendency and the stability of the organization.

Factor 4. Project. This factor refers to the users input to the selection of research and development projects. For effective research utilization, the client or potential client should have an open communication channel to the researcher. The client or potential user should have some influence on the selection and

[3]Essoglou, M. E., Naval Facilities Engineering Command, "The Linker Role in the Technology Transfer Process." Proceedings Briefing on Technology Transfer Projects, Naval Material Command, Wash., D.C., June 9, 1975.

[4]Ibid.



The model may be expressed in equation form such that:

$L_i = \sum \theta_1 C_1 + \theta_2 C_2 + + + \theta_j C_k$

Where

L_i = Linker index for an orginization $_i$

θ_j = A measure of factor utilization, θ_j range $0 \longrightarrow 1$

C_k = A measure of the factor contribution, $\sum C_k = 1$

Figure 8–1 Predictive Model of Technology Transfer. The linking mechanism necessary to achieve effective technology transfer is described by identifying the factors that contribute to movement of technology from the source of knowledge (supplier) to the utilization of knowledge (user/receiver).

approval of projects. In particular, potential user monitoring and consulting can be important in determining future utilization of the research output.

Factor 5. Capacity. The capacity of the user to utilize new and/or innovative ideas covers a wide spectrum of traits including venturesomeness, wealth, power, education, experience, age, self-confidence, and cosmopolitaness. These traits are measurable and their relative strengths can reveal the potential capacity of an individual within a user organization to utilize available technology.

Factor 6. Linker. The concept is that a person, referred to here as a linker, operates as a coupling device between the source and user of available knowledge. The concept, as described here, is that a linker (person) functioning within the user's organization would exhibit identifying traits and characteristics similar to those of the gate-keeper, opinion leader, innovator, and early knower of an innovation. The linker is often the intermediary in the technology transfer process.

Factor 7. Credibility. Credibility is an assessment of the reliability and accuracy of the information as perceived by the receiver. Credibility is a function of

the perceived reliability and accuracy of both the source and the channel through which the information flows. The extent of use and the rate of adopting research output correlates with the credibility of the available technology.

Factor 8. Reward. Reward, as referred to in the model, is the perceived and actual recognition of innovative behavior in the social system of which the individual is a member. Reward can be considered to be divided into two broad categories. The first category is intrinsic to the work itself. Examples of intrinsic reward are the opportunity to use skills, to gain new knowledge, to deal with challenging problems and to have freedom to follow up ones own ideas. The second category deals with extrinsic reward. Extrinsic reward is related to salary, administrative authority, association with top executives and similar benefits. Both intrinsic reward and extrinsic reward are important in influencing the utilization of new and/or innovative knowledge.

Factor 9. Willingness. Awareness, even first hand knowledge of a new and/or innovative idea, is not sufficient to assure its use. There must be a willingness and interest (or perhaps a better description is an internal motivation) to utilize a better method, process or concept. Willingness is a very personal element, yet it is often a critical point in the transfer and utilization mechanism.

Although this introduction to the nine elements of the technology transfer model, of necessity, has been brief, it does provide a foundation for the discussion that will follow.

What has been done then is to use the theoretical material that has been discussed as a means to look at an organization. The objective is to find out how an organization performs in terms of each of the nine factor areas of the model.

In order to get at the problem, several organizations that were similar in that they had a large number of graduate civil engineers were selected to be studied. The organizations were: Two public works centers of the Navy; one Naval Research activity; a department of the State of California; a large private engineering company; a consulting engineering group, and five field engineering divisions of the Naval Facilities Engineering Command. This gave a total of eleven organizations.

The selection of the organizations was intended to provide some data from the Federal sector and some data from the private sector. Each of these organizations is made up of a large number of professional type people most of whom are graduate civil engineers.

A point to make at this time is that it is much too early in the study for it to reveal specifically which organizations are either good or bad. In fact, the only person that would be considered eligible to receive the scores would be the director or commander of an activity. For this reason the activities are simply identified by number.

The instrument was designed around the model using Thurston differential type question construction. Each factor of the model was considered separately. Five questions were developed to measure the level of presence of a factor in the organization. An example of a question for the first factor, Documentation, is:

	STRONGLY AGREE	AGREE	NO OPINION	DISAGREE	STRONGLY DISAGREE
EXAMPLE OF QUESTIONS: FACTOR #1 METHOD OF INFORMATION DOCUMENTATION TECHNICAL AND/OR TRADE JOURNALS OFTEN HAVE USEFUL IDEAS ABOUT PROCESSES OR PRODUCTS THAT ENGINEERS CAN PUT TO PRACTICAL USE.	1	2	3	4	5

The respondent had the option of indicating: strongly agree, agree, no opinion, disagree, and strongly disagree.

The questions for Factor #2 were structured in a similar way. One example is:

	STRONGLY AGREE	AGREE	NO OPINION	DISAGREE	STRONGLY DISAGREE
EXAMPLE OF QUESTIONS: FACTOR#2 THE DISTRIBUTION SYSTEM COLLEAGUES WHO ATTEND PROFESSIONAL MEETINGS USUALLY PREPARE A REPORT OUTLINING THE NEW INNOVATIONS THAT THEY SAW OR HEARD ABOUT.	1	2	3	4	5

One last example is from the group of five questions to evaluate the factor Formal Organizations of the User. It is shown here.

	STRONGLY AGREE	AGREE	NO OPINION	DISAGREE	STRONGLY DISAGREE
EXAMPLE OF QUESTIONS: FACTOR #3 FORMAL ORGANIZATION OF THE USER MANAGEMENT ENCOURAGES INTER-DEPARTMENTAL COOPERATION AND ASSISTANCE AT ALL ECHELONS IN SOLVING PROBLEMS.	1	2	3	4	5

This methodology was applied to all nine factors. This then resulted in nine factors times five questions each or 45 questions in total. The questionnaire was designed to be relatively short and easy to read.

Nine of the eleven organizations were large enough to have over 200 professional employees. For these organizations the sample was about 200. The response was about 50%.

Two of the organizations were much smaller. The sample size was 50 with a 50% response of about 25.

The analysis technique that seemed most reasonable to us was the median chi square. The median for each factor was determined for the combined sample population of the eleven organizations. This established the reference standard. Then each factor of each of the eleven organizations was tested against the median using chi square analysis. If the test of a factor against the reference gave a chi square value of 3.84 or larger then it was considered significantly different at the 95% level. For this discussion the critical value was therefore 3.84. This is summarized as:

ANALYSIS TECHNIQUE
MEDIAN CHI SQUARE TEST
CHI SQUARE VALUES EQUAL TO OR GREATER THAN 3.84 SHOW A SIGNIFICANT DIFFERENCE FROM THE MEDIAN OF ALL ACTIVITY (D.F.=1, 0.95=3.84)
PLUS VALUES INDICATE A DIFFERENCE IN A FAVORABLE DIRECTION, NEGATIVE VALUES INDICATE A DIFFERENCE IN AN UNFAVORABLE DIRECTION.

Figure 8–2 is intended to show the most dramatic results from the study. The nine factors are listed on the abscissa. Activity #10 is the organization with the largest number of positive chi square values greater than 3.84. In contrast Activity #3 has the largest of negative chi square values greater than 3.84.

	RESPONSE BEST RESPONSE Activity #10	WORST RESPONSE Activity #3
1. DOCU	+31.737	−7.205
2. DIST	+11.032	−6.514
3. ORGA	+ 5.813	−7.170
4. PROJ	− 0.224	−5.761
5. CAPA	− 3.062	−0.123
6. LINK	+ 5.706	−12.173
7. CRED	− 0.427	−0.190
8. REWD	+ 0.085	−2.593
9. WILL	+ 0.558	−4.417

Figure 8–2 Organization Response. This chart shows the median chi square values for the activity with the most factors with chi square values significantly positive and the activity with the most factors that are significantly negative. Details of the chi square calculations are discussed in the caption to Figure 3.

Analysis would tend to support the argument that Activity #10 was performing very well in such factor areas as documentation, distribution, organization, and linker performance. In contrast Activity #3 appeared to have low performance in the factor areas of documentation, distribution, organization, project selection, linker performance, and willingness to accept new ideas.

What does high or low performance mean? At that point it is a value judgment on our part because we have not demonstrated the validity of the test. However, it would appear to us that organizations that are more effective in terms of their technology transfer accomplishments will tend to have higher positive chi square numbers.

Some of the organizations that were selected were those that we believed were superior and some were those that we believed were inferior in terms of their effectiveness at technology transfer. Our intuitive judgement was supported by the chi square tests.

One of the things that we have not done is to establish a weight or coefficient for each of the factors.

You can see in Figure 8–3 that each of the factors is considered separately. We have no reason to believe that they should or should not have an equal weight in terms of their effect on the technology transfer capability of the organization.

We would like to do additional research in order to determine just how important each of the factors are. How important is reward? How important is credibility? It is our strong feeling that these factors may be of different importance in different organizations depending upon organizational objectives.

In other words, we need to assign a coefficient to each of the factors in order to reflect its importance in an organization. It is our hope that the coefficients will be a constant for any specific sector of the economy, i.e., private research, government research, private engineering etc.

We have not attempted to add the factors together at this point in time. Because of this, we do not have a single index number that can be used as a grade or evaluation score for an organization.

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	ACTIVITY #1	ACTIVITY #2	ACTIVITY #3	ACTIVITY #4	ACTIVITY #5	ACTIVITY #6	ACTIVITY #7	ACTIVITY #8	ACTIVITY #9	ACTIVITY #10	ACTIVITY #11
DOCU	−0.061	−2.371	$\boxed{-\ 7.205}$	$\boxed{-6.885}$	−0.347	−1.040	−0.003	$\boxed{+\ 4.018}$	−1.013	$\boxed{+31.737}$	−0.000
DIST	−0.567	−0.002	$\boxed{-\ 6.514}$	−0.002	−1.584	−0.749	+0.208	+ 0.206	+0.942	$\boxed{+11.032}$	+1.804
ORGA	−0.936	−1.950	$\boxed{-\ 7.170}$	+0.248	$\boxed{+6.561}$	−1.305	+0.048	− 0.029	−0.002	$\boxed{+\ 5.813}$	−0.190
PROJ	+2.944	+1.389	$\boxed{-\ 5.761}$	−0.453	+3.028	−0.008	0.000	− 1.043	−0.031	− 0.224	−0.276
CAPA	−3.434	$\boxed{-4.741}$	− 0.123	−0.245	−2.206	−0.097	−2.977	− 0.001	−0.698	+ 3.062	$\boxed{+5.840}$
LINK	−0.024	−0.216	$\boxed{-12.173}$	+1.559	−1.242	−3.081	−0.176	+ 0.535	+0.713	$\boxed{+\ 5.706}$	$\boxed{+4.519}$
CRED	+0.431	−0.198	− 0.190	+1.502	$\boxed{-9.027}$	−1.557	+0.005	$\boxed{+\ 4.365}$	+2.828	− 0.427	+0.329
REWD	+0.530	−1.292	− 2.593	−0.227	−2.109	−2.279	−0.637	$\boxed{+20.389}$	−0.015	+ 0.085	+1.273
WILL	−2.355	−0.072	$\boxed{-\ 4.417}$	−0.783	−1.239	−0.006	−0.531	− 0.831	−1.527	+ 0.558	$\boxed{+8.571}$

Figure 8–3 A Median Chi Square Test Matrix of Activity vs. Factor. Above are shown the statistic, median Chi Square, for eleven activities vs the factors of the technology transfer model. The instrument was a self-administered questionnaire with five questions for each factor studied. The questions were multiple choice attitudinal, with five possible answers. The response rate was approximately fifty percent and was about the same for all activities tested. No follow up was used. The completed and usable response was approximately N=100 for each of nine organizations and approximately 25 for the other two. The reference median or expected value for the Chi Square was the median of all eleven activities. The [+] sign indicates that the activity was better than the median while the [−] sign indicates that the activity was below the median for the particular factor being tested. The Chi Square, I D.F. is 0.90=2.71, 0.95=3.84 and 0.99=6.63. Factors with either [+] or [−] Chi Square values greater than 0.9 probability of being different from the median of the eleven activities are contained in a box.

Figure 8–3 is the total picture of the study. All eleven organizations are shown. Note that Activity #1 is very close to the median for all factors.

Activity #3 is the one that was shown in Figure #2 with the large number of negative chi square values.

Activity #10 is the organization with the largest number of factors with positive chi square values.

Another consideration that we have examined and that we wonder about is the objective of the organization. Activity #10 is profit motivated as contrasted to a private or government research laboratory. This may be important and may tend to tell us something about the high positive chi square scores.

In review, we have taken the factors of the model and developed an instrument which attempts to measure each of the factors. We then administered the instrument to eleven different organizations.

In analyzing the data we have found a difference between the organizations. We have evaluated these differences in terms of the median chi square test. We found that there were significant differences between some of the factors. Some organizations have several factors that are positive and significant and some organizations have several factors that are negative and significant when the median chi square test is applied.

This tends to lead us to the feeling that it may be possible to identify (using the technique) organizations that are high performers in terms of technology transfer and those which are low performers.

One might postulate beyond this state that it conceivably could be true that certain actions could be taken to change the behavior of the individuals within the organization so that the organization would be more efficient.

I think when you get into the area of behavior changing you should think about the work reported by Dr. Dave Lingwood.[5]

Perhaps the most vulnerable aspect of this research is that we do not have a reference standard. A reference standard is needed in order to make the best use of these data. This will be the objective of future study.

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